Plant Parasitic Nematode Populations of Some Florida Soils Under Cultivated and Natural Conditions

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INTRODUCTION

Plant parasitic nematodes are recognized as pests of economic significance to the agriculture of Florida. The control of these pests by the use of chemicals is a relatively simple problem but the cost is high and is not always economically acceptable, particularly when the net return from a crop is low. This is especially true for most of the agronomic crops such as corn and peanuts. For these crops it appears that the use of rotations or of selected planting sites free from plant parasitic nemotodes offer the best means for reducing crop losses.

The effectiveness of these control measures depends to a great degree on knowledge of: (1) the species of plant parasitic nematodes which may be encountered, (2) the areas in which they may be expected to occur, and (3) the population levels which nematodes present may be expected to attain in a given site under a proposed cropping system.

The first two may be determined, for most species of nematodes, by an examination of samples of soil from the selected field. Knowledge of the third requires data from rotation trials conducted under conditions comparable to those of the proposed practices.

It would be most useful in farm planning and in advisory work if the necessary information could be predicted from data obtained by nematode surveys and presented in somewhat the same manner as is now used for land-use recommendations. Such an ambitious program would

require a very large effort, both for the detailed nematode survey and for the necessary rotation trials.

Some possible ways for obtaining the needed information without recourse to detailed surveys were considered. For example, it is reasonable to expect all organisms to show distribution patterns which reflect the interactions of these organisms with environmental factors. Such patterns often indicate the existence of a limiting factor in the environment. In the case of soil borne nematodes there is evidence for the occurrence of such a limiting factor in the soil, usually ascribed to soil texture. It is possible that other factors, inherent in the soil, may also be limiting. The presence of such factors, which could be isolated and identified, might be detected if a preliminary survey showed a degree of correlation between soil series and the presence or absence of certain nematodes. It might then be possible to use the information from the statewide soil mapping program to predict the non-occurrence of plant parasitic nematodes with a great saving of time and money. One of the objectives of the survey reported here was an investigation of the possibilities of such a procedure.

It is often suggested that nematode damage may be avoided by planting in virgin soil. The idea that virgin soils may be free of plant parasitic nematodes no doubt arose from the experience of growers with root-knot nematodes. They observed that when a crop such as cotton was planted in soil previously planted to cotton the roots were often heavily galled by these nematodes whereas, when new land was so planted, the galling was not noticeable. From similar observations, perhaps, arose the rather widely held opinion that plant parasitic

nematodes have to be introduced into arable soils from some other location. A second objective of these investigations was to determine whether or not there were specific differences between the plant parasitic nematode faunas of cultivated and uncultivated (virgin) soils.

In addition to the information obtained concerning possible correlations of nematodes with soil series, and their occurrence on cultivated and uncultivated soils, these investigations were expected to contribute to the list of plant parasitic nematodes known to occur in Florida.

LITERATURE REVIEW

Plant Parasitic Nematodes

The number of plant parasitic nematodes known to science has increased considerably in the last 25 years. Cooday in 1933 included 29 species as parasites of plants and 32 additional species as "parasites and semiparasites of doubtful pathogenicity" in his book, "Plant Parasitic Nematodes" (77). In 1941 Filipjev and Schuurmans Stekhoven (56) discussed 58 species which they considered to be plant parasitic and 25 additional species associated with plants which might be parasitic. In the most recent book on plant parasitic nematodes, Christie (37) mentions 125 species that feed on seed plants.

During the years intervening between the publication of the book by Filipjev and Schuurmans Stekhoven and the writing of that of Christie much work has been done on the taxonomy and host-parasite relations of nematodes. In this period Thorne (199) has published a revision of the order Tylenchida, Chitwood (28) has clarified the taxonomic status of the root-knot nematodes, and Franklin (58) has similarly treated the genus Heterodera. More recently Sher and Allen (168) have revised the genus Pratylenchus, Allen (2, 3) has reviewed the genera Tylenchorhynchus and Trichodorus, and Thorne (200) has described fifteen new species of Hemicycliophora. In addition a number of new genera have been described including three from Florida, Trophotylenchulus by Raski (156), Meloidodera by Chitwood, Hannon, and

Esser (33), and Hemicriconemoides by Chitwood and Birchfield (31).

The following review presents information concerning the recognized species of those genera of plant parasitic nematodes encountered in this survey. Included are feeding habits, some common host plants, and recorded occurrences of those found in the United States. The genera are discussed in alphabetical order since the plant parasitic nematodes do not constitute any distinct phylogenetic taxon. The term plant parasite is used loosely to include those species which may reasonably be considered by morphology and habit as suspect. Some species considered to be plant parasites may never be shown to be pathogens as defined by Mountain (136).

Aphelenchoides.

This genus is in need of revision. At present it includes some 60 or more species, most of which live in association with insects (37). The plant parasitic species are commonly called bud and leaf nematodes (17), from their mode of parasitism. Allen (1) completed a lengthy study in which he re-described and re-figured four species, A. fragarie, A. besseyi, A. subtenuis, and A. ritzemabosi. He synonymized six species or subspecies with the first, one each with the second and third, and two with the fourth. Two other species, A. cocophilus and A. parietinus, are considered valid plant parasitic species.

Five of these species are known to occur in the United States. Their distribution as outlined by Christie (37) is presented. A. besseyi is a parasite on strawberries from Maryland southward and is

found on rice in Louisiana and Arkansas. A. fragarie is parasitic on strawberries from Maryland northward in eastern United States and in California, Oregon, and Washington in the west. Additional hosts include Croft lily, bird's nest fern, daffodil, violets, and begonia (1). A. parietinus is primarily a parasite of fungi but may feed on buds or growing points of higher plants. It is widespread in the United States. A. ritzembosi is a pest on chrysanthemums and is found on 25 to 30 other plants including aster, delphinium, phlox, strawberry, and tobacco. This species is common in the United States. A. subtenuis has been reported from Virginia to Florida in the United States. Narcissus is the primary host. Aphelenchoides fragarie, A. cocophilus, and A. parietinus may be found in the soil, the others are apparently unable to live over any extended period there.

Aphelenchus.

Goodey (79) lists three species of this genus and states that the most widely distributed species, A. avenae, is not an obligate parasite although it can apparently function as a facultative parasite. Steiner (177) has described a fourth species, A. chamelocephalus, from diseased peanuts in South Africa.

Host-parasite relationships are not clear. Steiner (178) lists Irish potato, sweet potato, carrot, onion, narcissus, iris, anemone, cactus, cotton, and strawberry as hosts of A. avenae. He further states (180) that this species is a facultative plant parasite. The distribution of A. avenae is probably world wide. It has been reported from Europe, Africa, South America, and from Virginia, New Jersey,

New York, Mississippi, Illinois, Massachusetts, Oregon, Ohio, and South Carolina (178). There is no published information on its ecology beyond that concerned with host plants.

Belonolaimus.

This genus was described by Steiner (183) in 1949. Belonolaimus gracilis was the only species known until 1958 when Rau (158) published a description of B. longicaudatus. Observations recorded prior to 1958 may refer to either species.

These nematodes are elongate ectoparasites which feed primarily at the root tips or along the sides of succulent roots, suppressing their growth and causing development of abnormal root systems (37). All stages may be found free in the soil. Host plants include strawberries, celery, and sweet corn (39), cotton (82), fescue, Florida beggarweed, rye, wheat, oats, tomato, bell pepper, cowpea, crabgrass, Bermuda grass, (91), and hairy vetch (73).

These nematodes were described from Florida and are considered to be quite widespread in the southeastern United States. According to Holdeman (90), Belonolaimus sp. has been found in six counties in Virginia, five in North Carolina, 11 in South Carolina, six in Georgia and 24 in Florida. In addition Martin and Birchfield (133) have reported this genus in Louisiana and Hutchinson and Read (96) have reported its occurrence in New Jersey. Light sandy soils are considered the preferred habitat (37, 90), although it has been reported from a loamy sand in New Jersey (96).

Criconema.

Taylor (193) revised the genus in 1936 and placed eight species in it. Schuurmans Stekhoven and Teunissen (187) described four additional species in the genus Ogma which were transferred to Criconema by Goodey (79). Kirjanova (107) described three species from Russia in 1948 and Chitwood (30) described two new species from Florida in 1957, and prepared a new key which includes all the known species. Baker (12) listed 24 species in 1957 and gave the synonymy.

Little is known of the bionomics of the genus, except that they are apparently plant parasites. The known species inhabit leaf mold and soil. Most species are known only from the locality in which described. Three species, C. civellae, C. decalineatum, and C. spinalineatum, were described from Florida. Their hosts are, respectively, citrus, Ficus elasticha, and Zoysia matrella (30, 183).

Criconemoides.

These stout bodied nematodes are closely related to Criconema from which they were separated by Taylor (193) in 1936. They are all considered to be ectoparasites of plants, although the degree of pathogenecity has not been determined. Raski (153, 157) has provided the latest taxonomic treatment of the genus and lists thirty species.

Machmer (132) found numbers of Criconemoides sp. associated with a chlorotic condition of peanuts in Georgia. Raski (154, 155) reports that two species, C. xenoplax and C. mutabile, are frequently found around the roots of grape. These nematodes have also been found in such numbers as to suggest a pathogenic condition around the

roots of peach trees (27), tobacco (81) and lawn grasses (37).

The species known to occur in the United States, together with the plants with which they were associated are C. annulatum, from oak in Montana (193); C. citri, from sour orange in Florida (183); C. crotaloides, from fir and aspen in Utah (193); C. curvatum, from pine in Georgia (94), from sugarbeet in Colorado and Michigan (9), from snapdragon, lupine, and apple in California, grass in North Carolina, soil in New York and Vermont, and potato in Nevada (153); C. lobatum from potato in Nevada, sod in New York (153), and sugarbeet in Colorado (9); C. macrodorum from leaf mold in Virginia (193); C. mutabile from avocado, grape, strawberry, and sugarbeet in California (9, 132); C. ornatum from pine in Florida, Georgia, Louisiana, and Mississippi (153), and from sugarbeet in Colorado (9); C. parvum from Artemesia in Nevada (153); C. rusticum from alfalfa in Minnesota (196); and C. xenoplax from peach in New Jersey (197), grape in California, pine in Colorado, and soil in New York (153).

Ditylenchus.

The genus as it is known today includes 32 species (12). The existence of a number of races or strains defined more by host-parasite relationships than by morphology renders the nomenclature difficult to follow (37, 186). There has been no recent taxonomic treatment. Ditylenchus dipsaci, the stem eelworm, is of considerable economic importance as a plant pathogen (56). D. destructor, the potato rot nematode, is also quite important, although not so widespread. Only one species, D. intermedius, is reported from Florida (37).

Dolichodorus.

Three species have been described in this genus (67). Dolichodorus heterocephalus, the type species, was described from fresh water and was considered an aquatic species until Steiner reported its occurrence in celery fields in Florida (183). The other two species, D. obtusus and D. similis, were both recently described from California (4, 67), the latter from moist soil.

Ecphyadophora.

The genus is monotypic, and was known only from a single male until Tarjan (191) obtained males and females from several locations in Florida. This species, E. tenuissima, is probably parasitic on plants. It has been found in soil about the roots of pasture grass, citrus, and tomato.

Helicotylenchus.

This genus belongs to the subfamily Hoplolaiminae, which has been recently revised by Andrassy (8). The genus now contains six species.

Helicotylenchus nannus, the type species, has been reported from Washington, Oregon, Idaho, Montana, Wyoming, North Dakota, and Minnesota (19), California, Colorado, and Michigan (9), Alabama, Florida, Georgia, Louisiana, and Mississippi (94), Kentucky (23), and Maryland (99). Host plants include sugarbeet (9), alfalfa and flax (196), corn, small grains, strawberry, tobacco, forage legumes and grasses (23), asparagus, barley, clover, oats, rye, soybean, timothy,

vetch, and wheat (99).

H. erythrinae has been reported from Washington, Oregon, Idaho, Montana, Wyoming, North Dakota, Minnesota and Iowa (19), from California, Colorado and Michigan (9), and from Minnesota (196), Rhode Island (202), Maryland (99), and Florida (94). Known host plants include alfalfa, flax, pea, soybean (196), turf (202), pine seedlings (94), sugarbeet (9, 19), barley, clover, corn, oat, pepper, rye, soybean, timothy, and wheat (99).

A third species, H. multicincinctus, is reported in the literature with the above, but its range is not clear. Golden (66) states that it was represented in a collection of approximately 2,000 specimens representing 17 states of the United States. Steiner (179) indicates a wide geographic range for the species and reports it present in roots of Amaranthus spinosus from the United States. The remaining three species, H. africanus, H. iperoiguensis, and H. melancholicus, are not known to occur in the United States.

These nematodes are for the most part ectoparasites of plant roots. All stages may be found free in the soil.

Hemicriconemoides.

The genus was erected by Chitwood and Birchfield (31), to receive three new species from Florida and three species from Ceylon which had been placed in Criconemoides by Loos (123). The species are morphologically similar to Criconemodies and Hemicycliophora, and are found in similar habitats. There are no published records of occurrence of the three Florida species outside the state and little

is known of their host relationships. Hemicriconemoides wessoni was found around roots of Myrica cerifera, H. biformis from Quercus virginiana, and H. floridensis from pine and holly (31).

Hemicycliophora.

Tarjan (190), Thorne (200) and Luc (131) have made the most recent contribution to the taxonomic knowledge of this genus, which now contains 28 species.

Eleven species have been described from the United States. Hemicycliophora aberrans and H. tenuis were recorded from alluvial soil, and H. nana from soil about the roots of alpine plants in Utah (200). H. brevis was described from soil about the roots of hay and H. striatula from manzanita roots in California (200). H. gigas was described from clay forest soil in North Carolina (200). H. gracilis has been obtained from soil in Virginia, a peach orchard in Michigan, pine barrens in New Jersey, grass roots in North Carolina, and about gladiolus corms in Oregon (200). H. obtusa was collected from sugarbeets in Utah. H. parvana was described from soil about the roots of celery in Florida (190) where this species was found to feed readily on corn and beans but not on hairy indigo (161). H. rotundicaudata is known to occur in soil about conifers in Colorado (200). H. similis has been found on alfalfa in Nevada, peach in California and rose in Colorado (200). Hemicycliophora spp. have been reported from turf (183) and pine seedlings (94) in Florida, from tomato in Louisiana (55), raspberry in Maryland (99), sugarbeets in Minnesota and Montana (19), turf in North Carolina, and boxwood in

Virginia (175).

Heterodera.

The genus has been the subject of a considerable portion of the literature on phytonematology, much of which was reviewed by Franklin (58). Many of these papers are concerned with Heterodera marioni, the name under which a complex of species now known as Meloidogyne spp. was reported prior to 1949 (28). According to Christie (37) there are about 20 recognized species and subspecies. He gives their distribution in the United States as follows: H. rostochiensis, New York; H. tabacum, Connecticut; H. punctata, North Dakota and Minnesota; H. schachtii, sugarbeet producing areas, from Michigan to California; H. trifolii, California, Illinois, and Maryland; H. glycines, North Carolina, Tennessee, Missouri, Arkansas, Kentucky, and Mississippi; H. cruciferae, California; H. fici, California; H. cacti, widespread; H. weissi, common in eastern United States. Only the last two species have been reported from Florida.

Hoplolaimus.

Until recently this genus was held to contain four species, H. tylenchiformis, (the genotype) H. proporicus, H. coronatus, and H. uniformis. In 1958, Loof and Oostenbrink (122) found H. uniformis to be a synonym of Rotylenchus robustus and Andrassy (8) placed H. coronatus in the synonymy of H. tylenchiformis. In the same year Sauer (163) described Hoplolaimus gracilidens but added a note in proof transferring his species to the genus Rotylenchus. Host plants

of Hoplolaimus coronatus include corn, sugarcane, red clover, alfalfa cotton, and various grasses (37, 110). This form is considered to be widely distributed in eastern United States where it is an ectoparasite.

Longidorus.

There has been no recent taxonomic treatment of this genus. In 1939, Thorne (198) described and gave a key to four species, L. elongatus, L. georgiensis, L. maximus, and L. sylphus. Since that time a number of species have been described from Europe and Africa including L. multipapillatus (187), L. nudus (108) and L. monohystera (6). Christie (37) states that about ten species are known. At least two species are known to occur in the United States. L. sylphus is common in the Northwest (37) where it has been found to cause damage to peppermint (100). L. elongatus is a cosmopolitan species reported from grass sod in South Carolina and about citrus roots in Florida (198).

Meloidodera.

Chitwood et al. (33) described a single species of a new genus which they considered to be an intermediate between the genera Heterodera and Meloidogyne. The new species, Meloidodera floridensis, was found on roots of pine seedlings near Olustee, Florida. According to Hopper (94) this nemotode is widespread in the Coastal Plains area from North Carolina to Alabama. Preliminary studies (32) indicate that it is not strongly pathogenic to pine.

Meloidogyne.

Chitwood (28), in 1949, revised the complex of forms previously known as Heterodera marioni and selected the name Meloidogyne from the synonymy to contain them. New species and subspecies have since been described by Chitwood et al. (34), Loos (124), Lordello (126, 127), and Coetzee (45).

The morphology of the genus is such that separation of species is difficult unless fairly long series are at hand. Taylor et al. (194) have published a key to some of the species. Franklin (59) has reviewed the problems involved in identification. Records of host plants and of distribution will of necessity contain errors as a result of the identification problem. Adult females are sedentary endoparasites. Adult males and larvae are found free in the soil.

The genus is world-wide in its distribution. Seven species and subspecies occur in the United States. M. exigua has been found in the United States only at the New York Botanical Garden (28). M. arenaria arenaria has been reported from Florida (28) on many plants including peanuts and tobacco, in Georgia (70), and from Alabama (137). M. arenaria thamesi was described from ramie in Florida (34) and is probably widely distributed in south Florida (37). M. hapla may be found in potato fields from Maine to Minnesota, in Illinois, West Virginia and Virginia (28), on sugarbeet in Washington, Oregon, Idaho, Montana, Wyoming, Nebraska, Colorado (19) and California (9), on strawberries, red clover, alfalfa, vegetables and ornamentals in Kentucky (23), on tobacco in Maryland (99), and in soil in Alabama (137).

M. incognita incognita is widespread in southern United States (28), reported infesting celery, lima beans, pepper (28), and kenaf (174) in Florida, on cotton and tomato in Louisiana (55), common in Georgia (70), Maryland (99), and Alabama (137), and in roots of vegetables and ornamentals in Kentucky (23). M. incognita acrita is known from Georgia (28), Florida (174), California and Colorado (9), Louisiana (55), Maryland (99), and Alabama (137). It has been reported infesting roots of corn, muskmelon, soybean, sweet potato, tobacco, tomato, vetch, wheat (99), cotton (28, 55), sugarcane (134), kenaf (174), and sugarbeet (9). M. javanica javanica has been reported from Alabama (137), California (9), Georgia, Florida, New York and Texas (28), and Maryland (99). Host plants include peaches, lima beans, potatoes, cabbage, broccoli, and carnation (28), sugarbeets (9), snapdragons (99), and most agricultural plants (70).

Paratylenchus.

These nematodes are among the smallest plant parasitic forms. They are found free in the soil but often are found partially imbedded in root tissue. Twelve species have been described of which seven occur in the United States. The genus is widely distributed with a broad host list. Paratylenchus spp. have been reported from California, Oregon, Washington, Idaho, Montana, Wyoming, Colorado, North and South Dakota, Nebraska, Iowa, and Michigan on sugarbeet (19); from Florida, Georgia, Virginia, Maryland, New Jersey, New York (155), and Rhode Island (202) on turf; from Maine on beans (160); from North Carolina on boxwood (175); and from Louisiana on citrus, clover,

cotton, pecan, and tomato (55).

Reports of occurrence of individual species are limited. Paratylenchus anceps was described from California on Umbellularia (44). P. curvitata was found in New York in virgin peat soil and on roots of phlox (116). P. dianthus was described from Maryland on carnation (98), and has since been reported to feed on clover, corn, timothy, vetch, and wheat in that state (99). P. elachistus was described from Florida on ramie roots (183). P. hamatus was described from California on fig (201), has been found on clover in Maryland (99), and tentatively identified from Kentucky on strawberry (22). P. projectus is known from Maryland on pasture grasses (97), alfalfa, bean, clover, corn, lespedeza, and soybean (99). P. nanus is known to occur in North Dakota about the roots of grasses (44), in Virginia on zinnia (176), and in Maryland on wheat (99).

Pratylenchus.

These nematodes are usually found in shallow lesions in roots although all stages are common in the soil. Species of the genus are considered to be among the most important causes of root destruction in plants (168). The initial revision of the genus was made by Sher and Allen (168) in 1953. Taylor and Jenkins (195) list sixteen species and subspecies, of which ten are found in the United States.

Pratylenchus brachyurus has been reported from Georgia, Florida, Louisiana, South Carolina (168), Alabama and Mississippi (94), Kentucky (23), Maryland (99), and Maine (160). Host plants include, peanuts, corn, lupine (72), alfalfa, asparagus, barley, clover, grasses, oats,

rye, sorghum, soybean, strawberry, sugarcane and sweet potatoes (99); kenaf, lespedeza and okra (2). P. coffeae has been found on camellia in California (168), associated with black root rot of strawberry in Arkansas (47), and on alfalfa and red clover in Kentucky (25). P. hexincisus has been reported from Maryland (195), Texas (139), and Minnesota (196). Host plants are clover, corn, millet, rye, soybean, tomato (99), alfalfa, flax, pea (196) and sorghum (139).

Pratylenchus minyus is known from California, Nevada, and Colorado (168), Michigan (9), Idaho, Montana, Wyoming, North Dakota, Nebraska, Minnesota (19), Florida (51), Wisconsin (151), and Kentucky (25). This species has been found in soil around roots of pear, grape, dandalion, date palm, filaree, potato, and strawberry (168); feeding on alfalfa and pea (196), and associated with sugarbeet (9, 19) and strawberry (151).

Pratylenchus penetrans has been found in California, Washington, Oregon, New York, Vermont (168); Maryland (195), Kentucky (23), Louisiana (55), Maine (160), Minnesota (196), Colorado and Michigan (9), Arkansas (47), and Wisconsin (151). Host plants include pecan (55); alfalfa, flax and soybean (196); strawberry, snapdragon, tuberous begonia, lily, apple root, phlox, and peach (168); corn, tobacco, red clover, lespedeza, blue grass, tall fescue, and orchard grass (23). P. subpenetrans has been found only in Maryland on pasture grasses (195).

Pratylenchus pratensis occurs in New York, New Jersey, Washington, and Oregon (23); and in Maryland (99), Minnesota (196), Rhode Island (202), Maine (160), Florida (51), and Wisconsin (151). This species was found to reach its highest population density in roots of cereals

(144). It has also been reported from alfalfa, barley, beans, clover, corn, grass, oat, pea, rye, sorghum, soybean, timothy, tobacco, tomato, vetch, and wheat (99). P. scribneri has been found in Florida (168), South Carolina (94), Kentucky (23), Louisiana (55), Minnesota (196), and in California, Colorado, Washington, Oregon, and Idaho (19). Host plants include amaryllis (38), cotton (55), sugarbeet (9, 19), alfalfa, flax, soybean (196), corn, strawberry, and forage legumes (23).

Pratylenchus thornei is known from California and Utah (168), Colorado (9), and Idaho, (19). It has been found in soil around roots of grasses, oak, grape, bean, manzanita, nectarine, strawberry, walnut, cypress, pine, sugarbeet, and wheat (168). P. vulnus was described from California and is known to occur also in Oregon, Arkansas, Texas, and Maryland (168). Host plants listed by Allen and Jensen (5) are walnut, grape, fig, citrus, apricot, avocado, weeping willow, cherry, olive, peach, almond, plum, raspberry, and boysenberry. P. zeae has been found in Georgia, Florida, and South Carolina (168), and in Louisiana (55), Maryland (99), and Kentucky (23). Host plants include alfalfa, bean, corn, cucumber, grasses, tobacco, and tomato (99), sugarcane (55), kenaf (168), and strawberry (23).

Radopholus.

The genus was established in 1949 by Thorne (199) to receive two species, Radopholus similis and R. oryzae. A third species, R. gigas, was described by Andrassy (12) in 1954. In 1955 Allen (2) transferred the three species behningi, gracilis, and sostericola from Tylenchorhynchus to Radopholus. In the same year Hirschmann (88, 89)

made oryzae, behningi, and gigas synonyms of R. gracilis. In 1957 Luc (129) described R. lavabri and in 1958 Sauer (163) described R. inaequalis and R. neosimilis to bring the total recognized species to six. At present two species are known to occur in the United States. R. similis, the burrowing nematode, is widespread in the citrus producing area of Florida and is known to occur in Louisiana (37). The list of plants susceptible to this species is growing and includes more than 400 varieties at present. R. gracilis (synonym, R. oryzae) is known to occur in California, Louisiana, and Texas (37). Hosts include rice, grasses, and sedges (37).

Rotylenchulus.

This genus is monotypic. The single known species was described from Hawaii (117). The species has also been found in Louisiana, Georgia, and Florida (37). The host list includes coleus, croton, beet, tomato, lima bean, bushbean, eggplant, purslane, African marigold, papaya, poinsettia, and pineapple (119). Adult females are sedentary parasites. Larvae are found free in the soil.

Rotylenchus.

The genus has recently been reviewed by Andrassy (8). Most of the reports of distribution listed as Rotylenchus sp. or spp. may refer to species now placed in the genera Gottholdstrineria, Helicotylenchus, or Scutellonema. As presently constituted the genus contains only the species R. robustus and R. gracilidens. R. gracilidens was described from Australia and is not known to occur elsewhere (163). R. robustus (synonym, H. uniformis) has been found

on alfalfa in Maryland (99), and on flax and soybean in Minnesota (196). These are ectoparasites although they may be found at times with the anterior third of the body within the root.

Scutellonema.

Andrassy's revision of the Hoplolaiminae places six species in this genus (8). Scutellonema brachyurus was described from North Carolina parasitising red spiderlilies (181). It has been reported from South Carolina on sweet potatoes, tobacco, and Crotalaria striata (81) and on Clivia miniata in a greenhouse in Kentucky (23). S. christiei was described from Florida on Bermudagrass and spotted spurge weed (68). S. coheni has been reported from Florida on turf (71). For the remaining three species, S. blaberum, S. boocki, and S. bradys, there are no records of occurrence in the United States. Nematodes of this genus are known as ectoparasites. They may assume a semi-permanent position on roots but are commonly found free in soil.

Trichodorus.

The parasitic nature of a species of this genus was first demonstrated by Christie and Perry (40) in 1951. The genus was erected by Cobb (42) in 1913, and contained only one species, until Seinhorst described T. pachydermus in 1954 (165). In 1956, Colbran (46) described T. minor. Allen (3) in 1957 reviewed the genus and described ten new species. One of these, T. christiei, may prove to be a synonym of T. minor.

Distribution records for species occurring in the United States

are scant except for Allen's review (3). Trichodorus atlanticus was obtained from soil at roots of sand pine in Florida (3). T. aequalis has been found in soil in Oregon, in soil at the roots of toyon and manzanita in California, and in soil around pine and cactus in Colorado (3). T. californicus is known from soil around roots of Pinus attenuata, oak, redwood, bay, and willow in California, and from soil in Colorado (3).

Trichodorus christiei has the widest distribution of any of the species occurring in the United States. Allen (3) reports this species from azalea and cotton in Alabama, alfalfa, boysenberry, cotton, grape, peach, persimmon, and walnut in California, celery, tomato, and St. Augustine grass in Florida, artichoke and cotton in Louisiana, onion in Michigan, wheat in North Carolina, soil in Oregon, and blueberries in Maryland. In addition this species was found around the roots of sugarbeet in California, Washington, Oregon, Idaho, Montana, Colorado, Wyoming, Nebraska, and Michigan (9, 19).

Thrichodorus elegans has been found in soil about the roots of pine in Idaho (3). T. obscurus has been found about roots of manzanita in California, in soil in Oregon, and in sod in Virginia (3). T. pachydermus occurs in turf in Maryland (3). T. porosus has been found in soil around roots of Musa sp., boysenberry, grape, camellia, and walnut in California, and around azalea and Ilex rotundifolia in Alabama (3). T. primitivus has been found in soil about roots of mimosa in Maryland and boxwood in Pennsylvania (3). T. proximus was described from specimens found around roots of St. Augustine and

Bermudagrass in Florida (3).

Trophotylenchulus.

Raski described the only known species, Trophotylenchulus floridensis, from roots of Quercus falcata obtained near Winter Haven, Florida (156). Other hosts are magnolia and persimmon. Adult females are sedentary parasites, superficially imbedded in root cortex.

Trophurus.

The genus and two species were described by Loof (121) in 1955. One species, Trophurus imperialis is known only from the Netherlands. The second, T. sculptus, has been found in soil about the roots of manzanita in California (121). In 1958 Caveness described Clavaurotylenchus minnesotensis from soil about roots of sugarbeet in Minnesota, and from North Dakota (20). This latter species is considered congeneric with Trophurus sculptus, giving two species from the United States. Nothing is yet known about their bionomics.

Tylenchorhynchus.

Allen, who reviewed this genus in 1955 and described 22 new species, has this to say about it, "The genus Tylenchorhynchus without a doubt contains many more species than are included in the present study. Specimens were available from only a relatively few areas of the world. The number of new species found among those specimens examined indicates the need for careful study and comparison prior to making species identifications." (2, p. 130). At least 23 species are recorded from the United States, as indicated by this review. There

are certainly a number of others present which have not yet been described (37).

Tylenchorhynchus acutus has been found in soil around sugarbeets in Colorado (9), Washington, Oregon, Idaho, Montana, Wyoming, North Dakota, Nebraska, and Minnesota (19), and in soil from Utah (2). It has been found associated with roots of soybeans in Louisiana (93), sorghum in Kentucky (23) and Texas (139), and alfalfa, flax, pea, and soybean in Minnesota (196). T. affinis is known only from soil in California, and T. alpinus from soil at an altitude of 12,000 feet in Colorado (2).

T. brevidens has been found in soil around sugarbeets in California, Colorado, Michigan, Washington, Oregon, Idaho, Montana, Wyoming, and Nebraska (9, 19); in soil around roots of grasses in California, and in soil in Nevada and Utah (2). This species has been found among the roots of alfalfa, barley, clover, grasses, oats, pea, timothy, and wheat in Maryland (99), and on pea roots in Minnesota (196).

Tylenchorhynchus claytoni is either the most widely distributed species of this genus in the Southeast or the easiest to identify with certainty. The species is reportad from Louisiana (95), Florida, Georgia, Mississippi, and North Carolina (94), Arkansas, Alabama, and South Carolina (2), Kentucky (23), and Maryland (99). In addition the species is reported from Colorado, California (2), and Rhode Island (202). In North Carolina tobacco, corn, wheat, Sudan grass, and Irish potato were shown to be favorable hosts while Crotalaria spectabilis, peanut, pepper, cucumber, and mustard were unfavorable (109). It has

been found about roots of alfalfa, barley, bean, clover, corn, grasses, oats, pepper, rye, soybean, strawberry, sweetpotato, tomato, vetch, and wheat (99), and on Pinus elliottii (94).

T. conicus has been found in soil at the base of Chaemobodium sp., pine, and Arctostaphylos patula in California, and in soil at the base of cactus in Utah (2). T. cylindricus was described from the soil at the base of Prunus sp. in California and is known from soil around shadscale and juniper in Utah (2). T. dubius is considered to be common in the Southwest on native and cultivated plants (159); it has been found on strawberry in Arkansas (47), on strawberry and forage legumes and grasses in Kentucky (23), on turf in Rhode Island (202), and associated with clover, grass, oats, vetch, wheat, and barley in Maryland (99).

Tylenchorhynchus aremicolus is known only from the type locality in California where it was found around roots of grass (2). T. grandis has been found around roots of desert plants in Arizona, Artemisia sp. in Nevada, and in soil in California (2). T. latus was described from soil around the roots of Atriplex confertifolia in Utah (2) and from soil in Nevada. The species has since been found around sugarbeet roots in Colorado (9), Washington, Oregon, Idaho, Montana, and Wyoming (19) and about roots of alfalfa, flax, pea, and soybean in Minnesota (196).

Tylenchorhynchus leptus was found in moss and lichens at an altitude of 12,000 feet in Colorado, in soil and sod in Utah (2), and on alfalfa in Minnesota (196). T. lineatus has been found in soil at

the roots of cactus in Colorado and in soil in Utah (2). T. macrodens is apparently known only from soil in Utah (2). T. magnicauda has been found in Utah in bark beetle grass and in soil at the roots of maple. It has also been found in soil at the roots of conifer and spruce in Colorado (2).

Tylenchorhynchus martini has been found to be widespread in the sugarcane and rice fields of Louisiana and the rice fields of Texas (54). These two plants, together with dallis grass (Paspalum dilatatum Poir.) are considered to be hosts by Fielding (54). T. maximus was reported from soil in New York, California, Michigan, Utah, and Canada (2). It has been found around roots of tobacco and forage grasses in Kentucky (23) and in the root zone of alfalfa and soybean in Minnesota (196).

Tylenchorhynchus nudus was described from Canada (2) and has been found in soil around alfalfa, flax, pea, and soybean in Minnesota (196). T. ornatus has been reported only from Maryland, on barley (99). T. parvus has been found in California, Oregon, and Utah (2) and about roots of sorghum and various ornamentals in Kentucky (23). T. striatus has been found associated with pea and soybean roots in Minnesota (196), and T. superbus with roots of Pinus attenuata and Arctostaphylos sp. in California (2).

Species of Tylenchorhynchus are migratory ectoparasites, occasionally found attached to roots.

Tylenchulus.

Two species of this genus are known. Tylenchulus semipenetrans

was described by Cobb in 1913 (37) and T. mangenoti by Luc (130) in 1957. In both species the adult females are swollen sedentary parasites of roots, feeding with part of the anterior end permanently imbedded in tissues of the host. Adult males and immature stages of both males and females are found free in soil.

T. mangenoti is as yet known only from the Ivory Coast on the roots and rhizome of Dorstenia embergeri Mangenot. T. semipenetrans has a world wide distribution and in the United States probably occurs throughout the citrus growing areas (37). The primary hosts appear to be Citrus spp. (11).

Tylenchus.

Species of this widespread genus are free-living parasites or intermittant feeders on roots (79). According to Christie (37), they "probably feed on fungi, root hairs, and other thin-walled plant cells."

More than 100 species and subspecies placed in this genus since 1865 were removed to new genera as knowledge of the taxonomy of plant parasitic nematodes increased. The genus was given its modern characterization by Thorne (199) in 1949 and Andrassy (7) revised it in 1954, recognizing 20 species. Baker (12) lists 27. Since these nematodes are not known as pathogens there is little published information on their distribution in the United States. Tylenchus costatus has been found in Virginia in roots of poppy, rutabaga, and peony (56). T. davainii is widely distributed in the Western states (199). T. duplexus was described from grass in California (7). T. filiformis has been found in strawberry in Washington, D. C. (56),

and T. polyhypnus was described from a herbarium specimen of rye collected in Kansas (7).

Xiphinema.

In 1939 Thorne (198) discussed 10 species of this genus. Lordello (125) in 1955 presented a key which included 21 species. At present five species are known to occur in the United States. Of these Xiphinema americanum has the widest distribution. The species has been reported from Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina (94), California, Colorado, Michigan (9), Washington, Oregon, Idaho, Montana, Wyoming, North Dakota, Nebraska, Minnesota, Iowa (19), Arkansas (47), Maryland (99), Kentucky (22), New York (128), Rhode Island (202), and Wisconsin (151). It has been found on roots of laurel oak, azalea, and pecan (36), grape (87) and about the roots of alfalfa, asparagus, barley, bean, clover, corn, grass, lespedeza, muskmelon, oat, pea, pepper, rye, soybean, strawberry, sweet potato, timothy, tobacco, tomato, vetch and wheat (99).

Xiphinema chambersi has been reported from pine nurseries in Florida (94), soil in Virginia (198) and strawberries in Wisconsin (151). X. diversicaudatum was found to be widespread in the United States on roses in greenhouses (164) and has been found in soil in Virginia and Utah (198). X. index was described from soil about the roots of Ficus carica in California (201) and has been shown to be a vector of a virus disease of grape in that state (87). X. obtusum was described from soil about the roots of lemon in California (198) but has not been reported elsewhere than the type locality.

These nematodes are ectoparasites of plant roots. They remain free in the soil and feed by insertion of the stylet at the root tip and along the sides of roots (37). They are considered to be severe parasites of trees and shrubs (164).

Xiphinemella.

Two species are known. Loos described Xiphinemella ornatum from Ceylon and the other, Xiphinemella asseri, was described by Chitwood (29) from Florida. This latter species was found about the roots of Quercus falcata, Acer rubrum, and a fern, Pteris aquilina var. latiuscula (29). It has not been reported elsewhere.

Factors Affecting Distribution of Plant Parasitic Nematodes

There are two broad groupings of environmental factors affecting survival of organisms. Smith (172) has termed these density-independent and density-dependent, and has shown that some factors may act in both capacities. The density-independent factors are primarily physical and may include heat, cold, moisture, and food quality. Density-dependent factors may include quantity of food, parasites and predators, and available space. Factors in the first group would have more effect on the presence or absence of a species from a particular environment. Factors in the second group act on population densities. Nematodes of a species may be more or less abundant depending on these factors.

All of the factors permitting or denying survival of soil nematodes in a particular environment certainly are not known. In

many cases the "factors" are actually the resultant of several influences and the factor to which the resulting population or activity is attributed may not in fact be the only, or even the critical influencing one. This review serves to show the nature of the observations made by nematologists on such factors and indicates to what extent some may be limiting.

Temperature.

The effect of temperature depends on the preconditioning to which a particular species has been subjected. Soil borne nematodes are easily killed by temperatures of 50° C. in water in the laboratory. Nematodes able to withstand dessication may survive much higher temperatures. Overgaard Nielsen (149) found dessicated individuals of Plectus granulosus capable of withstanding 66° C. for four days and cites Rahm as showing that dessicated nematodes could survive temperatures of 272° C. for several hours. Hastings and Newton (84), working with "nema wool," which consists of dormant larvae of Ditylenchus dipsaci, found some larvae surviving temperatures of 140° F. (60° C.) for more than 150 minutes, while in a moist environment these larvae were killed by exposures to temperatures of 48 to 49° C. for 30 minutes. At the other extreme, Bosher and McKeen (16) were able to lyophilize dessicated larvae of this same species at -80° C. and store them in vacuo for a 28 day period without injury, while in water the larvae were killed after freezing at -80° C. for 20 minutes.

Observations of active nematodes in the laboratory have been aimed primarily at determining favorable rather than limiting temperatures. For example, Godfrey (62) found that with Heloidogyne sp.

infections of host plants are rare at temperatures of 10 to 12° C. and that below 16° C. the amount of root knot is much less than at 18° C. Mountain (135), in studying the effect of soil temperature on incidence of brown root rot, found that numbers of Pratylenchus minyus on two hosts increased with temperature up to 100° F. (37.8° C.). Ferris (53) found that larvae of Heterodera rostochiensis did not develop to maturity in host plants grown at temperatures of 85° F. (29.5° C.). The most rapid development in two hosts occurred at 65° F. (18.5° C.). Fenwick (52), working with this same nematode, found that emergence of larvae from cysts was virtually inhibited at 30° C.

Benedict and Mountain (13) found the optimum temperature for development of Pratylenchus minyus to be at least 90° F. (32.4° C.). They found that Tylenchorhynchus claytoni rarely occurred at temperatures below 80° F. but was quite common at 80 to 90° F. Dorylaims, on the other hand, were never numerous in cultures at soil temperatures above 70° F.

Graham (80) has shown that Pratylenchus spp. are capable of surviving over winter in South Carolina in roots or in soil. Benedict and Mountain (13) found that temperatures affected the percentage composition of nematode populations. Around wheat roots Pratylenchus minyus was most common from October to April but after April the percentage of P. minyus declined and Tylenchus filiformis and Tylenchorhynchus claytoni appeared.

Thus while some nematodes are capable of surviving extremes of temperature some, such as Heterodera rostochiensis, cannot reproduce at temperatures as high as those commonly occurring in Florida soils. It

appears from the above then that temperature may be expected to limit the distribution of a few species of plant parasitic nematodes but that each species would have to be subjected to test to determine the extremes critical for it.

Soil pH.

Nematologists are of the opinion that soil reaction does not limit the distribution of plant parasitic nematodes. Fenwick (52) found that altering pH from 3.2 to 8.1 had no effect on emergence of larvae of Heterodera rostochiensis from cysts. O'Brien and Prentice (140) found that soil reaction ranging from pH 4.26 to 6.26 had no effect on the intensity of disease caused by H. schachtii (rostochiensis) on potatoes, nor on the number of cysts present in the soil. Godfrey and Hagan (63) found no great difference in amount of infection of Heterodera radicicola (Meloidogyne sp.) in roots of pineapple or cowpeas growing in a "range of hydrogen ion concentrations between pH 4.0 and 8.5." They did find a "slight but unimportant reduction at pH values of 7.6 to 8.0 as compared with lower points." Smith (170) found a significant negative correlation between pH and cyst count of Heterodera rostochiensis for 53 peat soils but no significant correlation in the case of 25 sandy soils. Kincaid and Gammon (106) found the incidence of root knot caused by Meloidogyne sp. and of coarse root probably caused by Pratylenchus spp. to decrease in a series of plots where soil pH increased from pH 4.46 to 6.24.

Stephenson (188) studied the effects on Rhabditis terrestris of immersion in acid media prepared from hydrochloric, nitric, sulfuric,

formic, acetic, propionic, butyric, isovaleric, glycollic, lactic, oxalic, malonic, succinic, malic, tartaric, and citric acids. Preliminary experiments showed that the logarithm of the survival time was approximately proportional to the logarithm of normality. At 0.206 N the mineral acids had markedly greater effect than the organic. Differences were in part due to pH and partly to lyotropic effects of the anions. It was found with hydrochloric acid that toxicity increased as pH decreased from 2.00 down to 0.80. The chloride ion was considered non-toxic.

Moisture.

It is difficult to separate the effects due to soil moisture alone from other effects associated with its presence or absence. Godfrey (62) found that soil moisture in the range from 40 percent to above 80 percent of field capacity played only a small part in root knot (Meloidogyne spp.) development. Hollis and Fielding (92) found that populations of Tylenchorhynchus martini in soybeans were correlated with rainfall, high rainfall with low numbers and low rainfall with high. Similar correlations occurred between populations of T. martini and irrigation of rice. Johnston (101) found this species reduced in non-sterile saturated soils. He showed that a species of Clostridium produced a toxic principle under these conditions which killed the nematodes in from 15 seconds to two minutes. He suggested that anaerobic bacteria may be a factor in the reduction of nematode populations in water-saturated soils.

Godfrey et al. (65) studied the effects of drying of soil on

survival of Heterodera radicicola (Meloidogyne sp.). Larvae were found to persist in "surface dried soil" (not stirred) for 20 to 24 weeks, in soil maintained at the moisture equivalent for over 40 weeks, and in soil fluctuating between the moisture equivalent level and an air-dry condition for only 12 to 16 weeks.

Johnston (102) found the "optimum" moisture level for survival of Tylenchorhynchus martini in a silty loam soil to be from 40 to 60 per cent of field capacity.

Hastings (83) found dessication to be fatal to larvae of Pratylenchus pratensis (DeMan). Infested oat roots, air-dried for three days, contained no living nematodes of this species. When larvae of this same species were immersed in water 80 per cent were dead after four weeks but some survived after six weeks.

Godfrey and Hoshino (64) found that larvae of Heterodera radicicola (Meloidogyne sp.) survived for 3.5 minutes at a relative humidity of 50 per cent and for 25 minutes at 90 per cent. Eggs in masses survived for over two hours at 50 per cent and more than eight hours at 90 per cent.

The effect of moisture may be such that it causes changes in other factors such as oxygen concentration or osmotic pressure. Wallace (205) found relatively low emergence of Heterodera schachtii larvae from cysts in sand at water levels equivalent to from one to ten centimeters of pressure deficiency. He attributed this to low oxygen concentration in water around the cysts when sand is saturated. Emergence increased when the sand was drained by pressure deficiencies

from ten centimeters up to a maximum of 70 centimeters, after which a decline in emergence was noted. This decline was attributed to hindrance caused by surface forces of the water film above 70 centimeters.

Dropkin et al. (49) have shown that with eggs of Meloidogyne arenaria and Heterodera rostochiensis hatching was progressively inhibited as the concentration of several salts or of dextrose in water was increased. The inhibition was reversed when eggs or cysts were placed in water. The osmotic stress at which such inhibition starts was stated to be equivalent to 15 atmospheres of moisture tension, which is considered to be near the wilting point of plants in most soils. This inhibition would thus, in the opinion of the authors, act as a survival factor in soils subject to drying. Wallace (207) showed that permanent wilting of plants and total inhibition of larval emergences of Heterodera schachtii occur at about the same value of free energy, either that resulting from 16 atmospheres pressure deficiency or that from the osmotic pressure exerted by 0.65 molar sucrose or 0.42 molar sodium chloride solutions.

Organic Matter.

The abundance and state of organic matter present in soil has an effect on the number of micro-organisms and therefore an influence on the number of nematodes which feed on them. The effect of organic matter on plant parasitic species is not so direct. Linford et al. (120) found that decomposition of large amounts (50 to 150 tons per acre) of organic matter in soil was associated with reductions in

numbers of Heterodera marioni (Meloidogyne sp.). Decomposition was consistently followed by increases in population of saprophagous and predacious nematodes. It was hypothesized that these nematodes support a build-up of nematode trapping fungi, non-trapping fungal parasitas, predacious nematodes, and predacious mitas.

A number of such organisms are known to feed on plant parasitic nematodes. Goodey (74) described the fungus Varticillium sphearosporum which he found parasitic on Ditylenchus dipsaci. Duddington (50) has demonstratad an increased yield of potatoes resulting from addition of organic matter inoculated with a nematode trapping fungus to soil containing Heterodera rostochiensis. Capstick et al. (18) have demonstrated that at least one species of fungus, Harposporium oxycoracum, could be found parasitizing nematodes under naturally occurring conditions in the field.

Parker et al. (150) found nematode damage caused by Pratylenchus penetrans on fruit trees in New York associated with orchards in which clean cultivation had reducad organic matter content of the soil to a low lavel. They attribute improvements obtained with sod mulch culture in part to benefits derived from a more nearly natural biological balance achieved with increased organic matter content.

Host Plants.

The presence or absence of host plants would appear to be an obvious limiting factor to distribution of plant parasitic nematodes. In practice, however, the host list of most nematodes is found sufficiently extensive to include plants occurring in most localities

in temperate zones. Population levels are influenced to a great degree by host plants, but presence or absence of a particular host has not been shown to limit the range of plant parasitic nematodes.

Oostenbrink et al. (145) concludes that "there appears to be a close connection between cropping sequence and the composition of end damage (caused) by the nematode complex." Seinhorst (167) considers that plant parasitic nematodes may be divided into two groups: "A. Those showing a very close relation to crops rotation in their population dynamics, e.g., Heterodera species, Anguina species. B. Those being relatively independent of host crops for their persistence in the soil at a certain level of infestation. This level depends on soil type."

Soil Texture.

There are a number of reports in the literature which relate plant parasitic nematode distributions to soil texture. Most of these report particular combinations of consistence, structure, and texture as "soil types" and use the age-old terms light and heavy to describe these.

Bessey (14), in 1911, had this to say about conditions favoring root-knot (Meloidogyne spp.), "Root-knot is essentially a disease of light soils. Wherever the soil is sandy or contains a fairly large proportion of sand, other conditions being favorable, the root-knot nematode may be expected to thrive when once introduced. In heavy soils, on the other hand, the disease seems never to be serious. . . . Contradictory statements sometimes find their way into print, but they

are explicable in most cases when one understands the great popular confusion in the use of the words 'heavy,' 'stiff,' and 'light' as applied to soils. . . . Soils that dry out rather quickly, that do not cake hard on drying, and that are easily crumbled to a fine granular mass are favorable to these nematodes, while the reverse is the case for the difficulty permeable, hard-caking, clayey soils."

The conclusions of Bessey resulted both from experimentation and observation of naturally occurring infestations of Meloidogyne spp. Most of the following are the result of observation, usually after a more or less extensive sampling of an area or of crops in an area. Thus Sasser (162) states that in Maryland root knot was more prevalent in sandy loams than in heavier soils. Minton (137) found species of the genus Meloidogyne widespread in Alabama in soils ranging in texture from light sand to heavy clay. Jenkins et al. (99) in Maryland found Meloidogyne spp. to cause severe damage only in light sandy soil and found no large populations on clay or "clay-loam" soils. In California (9) 80 per cent of root knot nematode infestations of sugar beet were found in sandy soils. Meloidogyne incognita acrita was found in loam, sandy loam, silt loam, and clay loam, but apparently not in "sediment loam," silty clay loam, sandy clay loam, muck, and peat.

Poole and Schmidt (152) in North Carolina found "heavy" soils to be less favorable for the development of root knot caused by Meloidogyne spp. than sandy and sandy loam soils. They found diseased potatoes on Norfolk fine sandy loam and loamy fine sand and on Granville fine sandy loam. Heavy sandy loam soils on both sides of a heavily infested

light loamy sand remained free of the nematode.

Sleeth and Reynolds (169) conducted experiments in which Sesbania exaltata (Raf.) Cory was grown in various mixtures of Yuma Mesa loamy sand and Yuma Valley clay loam. When these mixtures were inoculated with Meloidogyne javanica the test plant was severely infested on the coarse textured mixtures and only lightly infested on the finer mixtures. They conclude that "it should be possible to determine from a detailed soil survey map those areas in which root-knot nematodes would likely be a serious hazard to crop production."

It has been suggested that the distribution of other genera and species is limited by soil texture. Christie (35) reported Belonolaimus gracilis (probably Belonolaimus spp.) to be widespread in Florida but that it had not been found in muck or marl soils. Van Der Vecht and Bergman (204) found Radopholus oryzae caused much retardation of growth in rice in a greyish brown loamy lateritic soil whereas plants grown in a heavy gray alluvial clay soil were only moderately affected.

Jones (104) found differences in population levels in species of Heterodera in replicated trials on two fine sands. Out of 17 host plants tested the number of Heterodera cysts obtained with all but two was greater in Spalding than in Cantley fine sand. Jones concluded that differences were evidently due to some inherent properties of the two soils.

Oostenbrink (142) found Pratylenchus pratensis and P. penetrans to be prevalent on sand and sandy peat soils, while P. minyus was prevalent on clay soils. He found that clay plots generally harbored smaller populations of Pratylenchus spp. than sandy peat soils. In

Maryland (99) Pratylenchus pratensis appeared better adapted to heavier clay loam soils, or to the somewhat cooler temperatures prevailing in the area where these soils were common. In the same survey P. brachyurus was concentrated in clay soils, P. zeae was collected only in the southern counties where a light sandy loam is common, and Pratylenchus penetrans showed no preference.

deFluiter (57) found Pratylenchus pratensis and Radopholus similis in Java in coffee plantations from sea level up to an altitude of 1500 meters in soils ranging in texture from heavy blue and brown clays, red mountain clays, and friable black forest soils, to sandy "kloet" soils.

Hoplolaimus coronatus was found most frequently in a clay or clay loam soil but only occasionally in a sandy soil in Maryland (99). Helicotylenchus spp. were considered best suited to clay loam soils in northern and western Maryland (99). In sugar beet fields of California, Colorado, and Michigan Helicotylenchus erythrinae was found most often in sandy loam and clay loam but specimens were also found in fine sandy loam, loam, silt loam, and silty clay loam. Helicotylenchus nannus occurred most often in clay loam (9).

In Maryland Tylenchorhynchus claytoni occurred most frequently in those counties in which the principal crop is tobacco and in which sandy loam is the principal soil type. T. brevidens was limited to clay loam soils, and T. capitatus was limited to sandy loam soils in the Eastern Shore counties (99).

In California (9) Trichodorus christiei was found almost

exclusively in sandy soils and Xiphinema americanum was found in sandy loam and clay loam soils. In Maryland (99) there was no indication that soil type or moisture conditions favored Xiphinema populations.

Caveness (19), in a survey of ten states which included eight "soil types" (textural classes), concluded that there was no direct evidence that any genus or species of nematode encountered was limited to or limited by any one "soil type." Dropkin (48) stated that there is no clear relation between soil type and the distribution of plant parasitic nematodes. Tyler (203) concluded that in comparison with other factors, soil texture is of minor importance in distribution of Meliodogyne sp.

On the other hand Raski (155), in discussing the factors that influence the expression of nematode injury to grape vineyards, lists soil type and stated that, "injury is more frequent and severe in the lighter, sandy soils and in soils low in fertility." Steiner (184) said that, "it has been demonstrated that certain nematodes are specific to muck soil, to peaty soils, to leaf mold, etc." Sleeth and Reynolds (169) would "expect a fairly close correlation between soil particle size and root knot infestation." Oostenbrink et al. (145) found that in the nematode complex Pratylenchus --Paratylenchus - Tylenchorhynchus, the species present on clay soils were different from those present on diluvial sandy soils. Seinhorst (167) states that "the distribution of all species of root lesion (Pratylenchus spp.) nematodes in the Netherlands and most probably also in other parts of Western Europe shows a close relation to soil type."

There have been some attempts to determine the precise effect of texture on function in nematodes. Tyler (203) stated that "the effect of a heavy soil is to make it more difficult for the larvae (of Meloidogyne spp.) to travel in search of a host, and this greater exertion may perhaps exhaust them more readily."

Dropkin et al. (49) suggested that the inhibition of hatching from egg or cyst which they observed in Meloidogyne arenaria and Heterodera rostochiensis may be a survival factor which explains in part the success of certain nematode infections in sandy soil. They apparently reason that a sandy soil dries out to the 15 atmosphere moisture-tension which inhibits hatching under conditions in which a finer textured soil retains enough moisture to permit hatching but prevent movement to a suitable host. Thus in sandy soil a percentage of eggs survive adverse conditions.

Overgaard Nielsen (149) cited measurements made by Donat which show that the percentage of pores having a diameter 20 microns or smaller was 96 percent for clayey loam, 63.5 percent for a field soil, 20 percent for "schluff" sand, and 4 percent for the 0.5 to 1.0 mm. fraction of a quartz sand. He concluded that, since most nematodes have diameters in the range 20 to 50 microns, pore size is less important as a distribution factor with nematodes than with micro-arthropods. He stated "It is a general rule that the smaller the animal, the better they are fitted for living in the soil." It would seem that while pore size does not facilitate distribution as concluded by Nielsen, it certainly could inhibit distribution, or at least movement.

Wallace (208) studied the movement of Heterodera schachtii and

of Ditylenchus dipsaci in different soil fractions at varying moisture tensions. He found that the nematodes did not disturb surrounding particles and that they were unable to constrict their bodies to pass through pores smaller than their own diameter. He concluded that nematodes are restricted to existing channels in the soil. He also found that pores having a diameter less than 20 microns constitute a barrier to movement. The relationsip of pore size and moisture holding capacity to nematode movement was found to be optimum in the 150-250 micron fraction of soil in the case of Heterodera schachtii larvae. In another paper Wallace (209) studied the mobility of these nematodes in horizontal tubes containing different soil fractions at different suctions. His results led to the conclusion that "there is a simple relationship between the length of the eelworm and the size of the particles for maximum mobility" and he comments as follows: ". . . if further investigations suggest that there is a simple relationship between eelworm length, particle size and mobility, it may be possible to throw some light on the problem of population numbers and the migration of eelworms in different soil types."

These observations on factors influencing distribution of plant parasitic nematodes may be summed up by quoting Steiner (185):

> The soil through its structural make-up offers plant nematodes the conditions of a cavernicolorus life; such as, 1. pore space with moisture saturated air, 2. a film of moisture over the crumbs of soil, 3. a narrow temperature amplitude slow in its movements, and 4. good protection from light and the lethal action of the rays of the sun. Thus a porous soil is particularly suitable for our nematodes; light sandy soils have long been known to favor plant nematodes and especially to promote their spread. Heavy clay soils are not exclusive and preventive of nematode infestations but they have a restraining effect on their spread.

In general soil factors that favor plants also are optimal for plant nematodes. But in the end the presence or absence of a host plant governs all these factors.

Florida Soils

Henderson and Smith (86) have given a succinct introduction to Florida physiography and soil genesis. They find that all but three of its 67 counties lie in a low coastal plain. The dominant factors in soil formation in Florida are relief and parent material. Drainage is variable. In the north and west stream drainage is common. In the central area of the peninsula surplus water collects in sloughs. Parent material consists of alluvial deposits along streams, organic deposits in low areas, limestones, marls, and marine deposited mixtures of sands, silts, and clays.

Gammon et al. (60) have published physical, spectrographic and chemical analyses of some Florida soils. The development, characteristics, classification, utilization, and management of Florida soils are discussed by Henderson (85), and a key to their identification is given. Up to 1939 "more than 50 well established soil series and more than 100 soil types had been identified." By 1950 at least 260 soil types had been established although only one third of the state had been mapped (171). At present the number approaches 500.

The soil series and soil type used in soil classification are analogous to the genus and species used in classifying organisms, and are as useful in characterization. Soil series are differentiated mainly on ". . . the kind, thickness, and arrangement of horizons, and their structure, color, texture (except A horizon), reaction, consistence,

content of carbonates and other salts, content of humus, and mineralogical composition" (173). The soil type differs from other soils in the series by the texture of the A horizon. The soil type name consists of the soil series name together with the textural class name of the A horizon.

Except for detailed surveys soils are mapped by soil associations, groups of soil series occurring in the mapped area which have a number of characteristics in common. Smith and Henderson (171) group the Florida series into: (1) well-drained sandy loams and loamy sands, (2) imperfectly to poorly drained sands and loamy sands, (3) poorly to very poorly drained peats and mucks, (4) well to excessively drained sands and loamy sands, (5) well-drained limestone and poorly drained marl, (6) alluvial sands, loamy sands, and sandy loams with variable drainage, (7) tidal marsh and mangrove swamp, and (8) cypress and gum swamps.

The soils of Group 1 are found in the northern half of the north-western tier of Florida counties. Series included are: Norfolk, Ruston, Red Bay, Greenville, Orangeburg, Shubuta, Angie, Bowie, Carnegie, Dunbar, Faceville, Magnolia, Marlboro, and Tifton, with occasional islands of Lakeland series. These are well-drained sandy loams and loamy sands which have developed from marine deposits of non-calcareous sands and clays for the most part.

The soils of Group 2 are widely distributed over the state in areas termed "flatwoods." Among the series included are: Leon, Immokalee, Plummer, Rutlege, Scranton, St. Johns, Ona, Rex, Bladen,

and Arzell. Soils of Group 4 are sometimes found on higher elevations in association with these. The principal characteristics shared by Group 2 soils are: (1) imperfect to poor drainage, and (2) gray to black colors in the surface horizons with lighter colored subsoils. They are derived from sands, limestones, clays, and a variety of other parent materials. Most of the surface horizons are classed as sands or fine sands.

The soils of Group 3 are organic soils occurring in the central and southern parts of Florida, mainly in the Everglades. They have developed from the decay of sedges, grasses, and other plant material, and are underlain for the most part by limestone. The principal series are Everglades peat, Loxahatchee peat, Okeelanta peaty muck, and Okeechobee muck.

The soils of Group 4 are well to excessively drained sands and loamy sands which occur in the southern half of the northwestern tier of counties and in the central counties of the peninsula. Among the series included are: Arredondo, Archer, Eustis, Fellowship, Gainesville, Lakeland, Orlando, Ft. Meade, and Kanapaha. They have developed from deep beds of marine deposited sands and clays or from limestone and calcareous sands.

The soils of Group 5 include Rockdale sands and sandy loams, Perrine, Ochopee and Flamingo marls, and Hialea muck marl. All are in the southern tip of the state.

Group 6 is comprised of alluvial soils occurring along river bottoms and in flood plains. Groups 7 and 8 are unclassified soils of

tidal marshes and mangrove, cypress, and gum swamps.

Other classifications of Florida soils have been made. For example, those of Leighty et al. for soil associations of Hillsborough County (114), Dade County (113), and Sarasota County (112) which take into consideration the characteristics of the soil series of those counties to permit a more or less natural grouping.

Thus we find that the soils of Florida have been studied and classified in such a manner that they may be characterized by a name which conveys or connotes a number of physical and chemical properties. These are the resultants of the interactions of climate, parent materials, relief and other factors over a period of time, and may be supposed to reflect their environment.

Methods and Procedures

The presence or absence of a particular species of nematode in an environment is known to us only to the extent that our methods of detection are capable of determining presence or absence. Seinhorst (167) recently made the comment "Population studies on other nematodes (than Heterodera schachtii and H. rostochiensis) are of very recent date. This is mainly due to the fact that no effective extraction methods both as to percentage recovery and economic use of time and manpower were known in the past."

Separation of Nematodes From Soil.

Nematodes are identified by morphological and anatomical characters. This requires that nematodes be separated from soil or

other substrate and observed under a microscope. Various methods have been devised for this purpose. Cobb (43) used a combination of settling and wet sieving. His process is reviewed in some detail to indicate the nature of the separation problem. The relatively slow rate of settling of nematodes makes possible an initial separation from coarse sand and gravel by allowing a suspension of nematodes and water to stand until most of the coarse material has settled. The supernatant liquid is then decanted over a nest of sieves, which are washed with a gentle stream of water to allow smaller particles of soil to pass through. Each stage is repeated until examination shows no nematodes remaining among larger particles before these are discarded. Near the end an unknown percentage of the original nematodes are contained in a comparatively large volume of water together with enough silt and clay to make direct examination tedious. Some of this material is eliminated by a second decanting in which nematodes are allowed to settle while the supernatant liquid is discarded.

Baermann (10), in 1917, published a method which utilizes activity of the nematodes for separation from soil. In this method a soil sample was placed on a circle of cloth supported by a sieve immersed in a funnel filled with water. The end of the funnel was closed by a short length of rubber tubing which was clamped off. In experiments in which a known number of Ankylostomum larvae were added to sterile soil and processed by the procedure, Baermann was able to obtain 87 percent recovery.

Overgaard (148) modified the Baermann apparatus by enclosing a

battery of the funnels in a box containing a 16-watt light at the top, which heated the water in the funnels from an initial temperature of 13° C. to a final temperature of 30° C. in about one hour. Total recovery after 12 hours varied from 88 to 100 percent with fresh soil samples. The same percent recovery was obtained from soil samples stored in corked glass tubes at 0 to 5 degrees centigrade for up to 41 days.

Christie and Perry (41) developed a method which combines wet-sieving with the Baermann technique. In their procedure the soil sample is roiled in a cylindrical container with about one half gallon of water, allowed to stand a few seconds while the coarse particles settle and the supernatant mixture is then decanted slowly over two nested sieves. The roiling and decanting may be repeated one or more times. Residue on the nested sieves is then washed with a gentle spray of water. Material on the upper sieve (usually 30 mesh) is discarded, and material on the lower sieve (usually 200 mesh) transferred to a layer of cloth suspended in the Baermann funnel. Nematodes are drawn off in a small volume of water after about 18 to 20 hours. Later Christie substituted a ring of aluminum pipe two inches high with a square of cloth stretched over the lower end for the cloth sack used earlier. A number of other methods for separation of nematodes from soil or plant tissue are discussed by Goodey (75), Tarjan et al. (192), and Chapman (24, 26).

Seinhorst (166) developed two types of apparatus for the determination of numbers of nematodes in soil samples. The second apparatus, a simplified version of the first, uses a countercurrent of

water to separate nematodes from a soil suspension settling through glass tubes. The diameter of the tubes and the speed of the counter-current control the rate of fall of nematodes and soil particles in accordance with Stokes' law. About 85 to 90 percent of the nematodes in a 500-gram sample are recovered. A final separation of nematodes from small particles is made using a modification of the Baermann technique.

Survey Procedures.

Methods for quantitative separation of nematodes from soil are now available, as indicated above. The best of these, however, requires considerable time for separation and identification of nematodes. The number of such samples that can be processed by an individual is therefore limited and affects to a great degree the nature and extent of soil borne nematode surveys.

The liklihood of detection of any soil nematode is dependent on distribution, population density, and the number of samples taken in the field. Jones (103) has shown that with Heterodera a true picture of the population could only be obtained by the separate counting of nematodes in a very large number of small samples. On the basis of 100-gram samples drawn from a mixed bulk of soil, certainty of detection is not reached until field populations attain a level of 50 to 60 million cysts per acre. The usual field practice is a compromise between accuracy and ability of the laboratory to process samples. A number of small samples are taken and mixed thoroughly. From this bulk a small volume is submitted to the laboratory. The accuracy

attained is adequate for the purpose--advising growers when to change crops in rotation schemes.

Oostenbrink (143) reported that for advisory work a bulk sample of 1 kilogram obtained by taking 50 small diameter cores per hectare (124 cores per acre) was adequate. For a survey to detect presence or absence more cores are needed. He considered that in the laboratory the examination of one to two sub-samples of 100 to 200 cubic centimeters of soil from the bulk sample are normally adequate for detecting dangerous concentrations of nearly all plant parasitic nematodes, since at this concentration there will be "some tens to some thousands of specimens per 100 cc. of soil."

The objective of the survey determines the procedures employed. Overgaard Nielsen (149) outlined two essentially different procedures for study of a component of the soil micro-fauna as follows: (1) an investigation in great detail of the qualitative and quantitative distribution of the group in an area of some few square meters, or (2) investigation of a variety of biotopes from a number of localities. His experience indicated that with the former method differences in the composition of the fauna could rarely be demonstrated. With the latter method, provided the localities can be defined in a reproducible way, enough localities can be investigated "that mere experience can give the clue to the basic phenomena deciding the type of distribution, and also a fairly clear picture of the physical and chemical factors, the knowledge of which will be of value in future research work." In his study sites were selected for sampling in two main groups, mineral

and organic soils. The mineral soils included a range from pure sands to heavy clay soils, which could be easily recognized and defined. In the field at each locality about 10 cores of one square centimeter diameter were taken to a depth of five centimeters and each core was separately examined. Occasionally samples were taken to greater depths to determine vertical distribution. Abundance was indicated by a scale of relative values.

Jenkins et al. (99), in determining the distribution of plant parasitic nematodes occurring in Maryland, took samples at random throughout the state. Samples were obtained from 1,210 different farms and gardens. Each sample contained soil and roots from eight to ten cores, one inch in diameter and six to eight inches deep. One pint of soil from each sample was then processed by the Christie-Perry technique. Field data included location, host plant, symptoms of injury if present, general soil type (textural class), soil temperature, estimated soil moisture, and date. Data were recorded on a punch card system to facilitate interpretation. No attempt was made to take samples from uncultivated sites.

In a study of nematodes associated with sugar beet production in selected northwestern and northcentral states (19), sampling was based on sugar beet acreage planted. One field, representative of each 300 acres of production, was selected by field men on soil types representative of the field man's particular area. Two samples from each field were taken. One was from the center of an infested area, or the center of the field if no infestation was evident. The second was taken at least 50 yards from the first. Each sample consisted of

one whole sugarbeet, including the top, and one quart of soil. The quart of soil was taken from a volume one foot square and 10 inches deep surrounding the beet. These samples were then sent to the nearest of eight laboratories for processing by a team of trained technicians and a nematologist. Plant parasitic nematodes were identified to genus and to species if possible. Population densities were estimated as number per quart of soil and classified into eight categories. Population per sugarbeet sample was recorded in five categories from very rare to very abundant.

Kirjanova (108) cooperated in a study of the biocoenosis of the soils of Golodnaya steppe, the aim of which was to determine the specific composition of the entire soil fauna. Due to the amount of labor involved, nematode investigations were confined to two plots, one in an irrigated cotton field and the second an irrigated virgin plot nearby. Each field sample consisted of five cores taken to a depth of 40 centimeters. Each core was divided into four layers: 0 - 10, 10 - 20, 20 - 30, and 30 - 40 centimeters. Corresponding layers from each core were bulked and mixed. From this a volume of 125 cubic centimeters was processed by wet-sieving. The nematodes were picked by hand from the residue on each sieve and the number of each species counted.

Schuurmans Stekhoven and Teunisson (187), in surveying the free-living soil nematodes of Albert National Park in the Belgian Congo, selected a number of different habitats which were described in terms of soil, plant association, and elevation. Samples collected from the sites were mixed and 75 cubic centimeters were then wet-sieved through a series of sieves of increasing fineness. Nematodes were picked from

the residue, determined to species, and counted. Debris on each sieve was washed into water and diluted to a known volume. An aliquot was then taken and the number of organic and inorganic particles were counted for each of the separates obtained. These data were then plotted on a graph in an attempt to obtain a picture of the influence of particle size and organic matter content on the nematode fauna of the site in question.

For the nematologist all these procedures convey the same picture of compromise between the small number of samples which can be processed to identification, and for which the necessary physical data can be measured, and the large number of samples needed to give a true picture of nematode distribution and the factors of significance in determination of it.

The procedures which are considered successful are those used to determine presence of plant parasitic nematodes in numbers sufficient to cause crop losses. These, for the most part, depend on a background of experience and are usually expressed in relative terms.

The most successful approach to a determination of the relationship of species to a factor affecting distribution (textural class) is that used in the study of nematodes associated with sugarbeet production (19) because it was conducted throughout in accordance with a systematic sampling plan, and because a sufficient number of technicians were available for taking the necessary samples and counting the nematodes found.

OCCURRENCE OF PLANT PARASITIC NEMATODES

Methods

The Survey.

The methods used in selecting sites for soil borne nematode surveys have been discussed in the preceding review. It was pointed out that the number of samples that can be processed is small because of the time required for determinations of nematodes to species. The measurement of physical and biological factors in the environment which might affect the distribution of nematodes would further reduce the time available and restrict the number of samples.

With this in mind the survey was planned to take advantage of the information already available in the form of soil surveys which, based on soil series or associations of series as they are, contain much information on the known physical factors in soils.

A number of sites were therefore selected in consultation with soil surveyors of the Florida Agricultural Experiment Stations. The main criteria were: (1) inclusion of soil series from each of the principal soils associations used in mapping Florida soils, (2) selection of soils to include a wide range of textures, (3) selection of sites which could be readily located in the field and for which the soil classifications had been correlated (correctly determined) to agree with those of the Southern Regional Survey, and (4) inclusion of both cultivated and uncultivated sites in close proximity.

Most of the samples were obtained from Alachua, Suwannee, and Gadsden Counties. The soils of these counties are representative of those on which the principal agronomic crops of Florida are grown. These have not been surveyed as intensively as have those of the central ridge section of Florida where most of the citrus crops are grown, and therefore the information obtained might be expected to contribute to the knowledge of the occurrence of plant parasitic nematodes in the state.

In addition to these samples, a number were obtained from the muck soils of the Everglades, the marls of Dade County, and the flatwoods soils in St. Lucie County through the cooperation of the staff of the Everglades Experiment Station.

Determination of the soil series at each site was made either by a person qualified as a soil surveyor or they were verified by a soil surveyor from a description and samples of the profile. In the case of samples obtained from cooperators the cooperator selected areas in which the soil series was known to him or which could be verified by a soil surveyor.

Sampling Procedures.

After sites had been selected and located in the field from soils maps or with the aid of a soil surveyor, they were sampled by two methods. Uncultivated soils were usually sampled by profile. A small pit was dug at each site and samples of approximately one half a cubic foot were cut from the sides in the various profiles. Samples were obtained which included some roots from the dominant vegetation on

the site.

Cultivated soils were sampled with a one-inch diameter tube sampler to a depth of eight to 12 inches. Each sample consisted of sufficient cores, usually three, to provide approximately 150 cubic centimeters of soil. The cores were taken from the root zone of the crop and usually included a quantity of roots. From three to eight such samples were obtained at each cultivated site, although more were often taken from sites of agronomic or horticultural trials.

All samples were placed in polyethylene bags to maintain the moisture at field levels until they could be processed. On field trips of more than 24-hour duration samples were kept in a portable icebox containing crushed ice until they could be brought in to the laboratory. On returning to the laboratory all samples were held at approximately 34° F. until they could be processed.

Processing Procedures.

The Christie-Perry technique was used to process all samples prior to July, 1958, when four Seinhorst elutriators (166) were set up in the laboratory. These procedures have been discussed above.

For the Christie-Perry procedure a volume of approximately 150 cubic centimeters of soil was roiled with one-half gallon of water for 20 seconds, allowed to settle 40 seconds and decanted over a 30 mesh and a 325 mesh sieve nested together. A second volume of water was added to the soil and the process repeated. The debris on the lower sieve was placed in a Baermann funnel (41). After 24 to 48 hours the entire contents of the funnel were drawn off through a small (2-inch diameter) 300 mesh sieve. The sides of the funnel were washed to remove adhering

nematodes and the wash water allowed to run over the same sieve. The nematodes were then washed from the sieve into a small shell vial, and were either preserved with 5 percent formalin, or placed in the refrigerator until they could be examined.

Roots obtained with the samples were washed and macerated in a Waring blender for 20 seconds. The blended material was then decanted over the nested sieves and handled in the same manner as were the soil samples.

When the bank of Seinhorst elutriators was obtained the volume of soil processed from each sample was increased to 250 cubic centimeters. The elutriator was used as a separatory device to replace the decanting and settling methods used in the Christie-Perry technique, since this method had been found more efficient with muck or fine textured soil samples. Following this initial separation the sample was processed as for the Christie-Perry technique.

Where there was doubt concerning the texture of the surface horizon of any sample the percent sand, silt, and clay were determined by the Boyoucos hydrometer method. The textural name was then assigned by reference to the "soils triangle" published by the U. S. Department of Agriculture (173).

Identification.

Nematodes were identified to genus under a stereoscopic microscope at a magnification of 45 diameters. The plant parasitic nematodes which could not be further identified at this magnification were mounted in water and examined with the oil immersion lens of a research

microscope.

So far as possible all mature plant parasitic nematodes from samples obtained from the uncultivated sites were determined to species by reference to the original description or to the latest monographic treatment of the genus.

In the case of the cultivated soils, where the number of samples as well as the total number of plant parasitic nematodes was large, only a few nematodes of each genus were identified to species.

For the most part the generic and specific names assigned to the specimens conform to the current literature. One exception to this is the use of Hoplolaimus coronatus Cobb which fails to recognise the revision of Andrassy (8), who placed this species in synonymy with H. tylenchiformis Doday. Based on Andrassy's redescription of this species there appears to be sufficient reason to maintain the identity of H. coronatus distinct from H. tylenchiformis to avoid losing these records of occurrence of an apparently valid species.

Results and Discussion

Survey of Soil Series.

The soil series examined are shown in Table 1, grouped into soil associations according to the interpretation of Smith and Henderson (171).

A total of 369 samples was examined from 106 sites on the 31 soil series included in the survey. A list of the species found, together with the soil types in which they occurred, is presented in

Table 2. Detailed records of the findings at each site are recorded in the Appendix (Tables A to F).

The predominant genera found in the well-drained sandy loams and loamy sands (Table 3) were Criconemoides, Pratylenchus, Trichodorus, Xiphinema, and Helicotylenchus. Species of these nematodes were found in almost all of the soil series of this association.

Species of Belonolaimus occurred in only two samples from a single soil series. The possible significances of this finding will be discussed below. Species of Hoplolaimus were found in only 10 samples. This result is in contrast to that obtained by Jenkins et al. (99) in Maryland where this genus was found most often in fine textured soils.

Specimens of Tylenchorhynchus and Paratylenchus were found in only three samples. These genera are not encountered very frequently in Florida and these results are therefore not surprising.

Specimens of Meloidogyne were found in fewer samples than expected. Species of this genus are widespread in cultivated soils in Florida. It is possible that more attention to collection of root samples would have detected more occurrences of this genus.

The occurrence of the genera of plant parasitic nematodes in imperfectly to poorly drained sands and loamy sands (Table 4) presents a somewhat different picture. The predominant genera were Hoplolaimus, Helicotylenchus, Belonolaimus, Criconemoides, and Trichodorus. Specimens of Hemicycliophora were fairly common, and specimens of Tylenchorhynchus were quite numerous in some turf samples from Leon

soils in Duval County. The occurrence of Dolichodorus in this group is of interest. These nematodes were long considered to be aquatic and may be associated with moist or frequently flooded habitats.

The low numbers of Pratylenchus and Xiphinema may be significant but the total number of samples is too small for any conclusions to be drawn from this. The occurrence of the genus Trophurus in samples from a Rex soil is of interest. This genus was recently described from specimens collected in the Netherlands (121) and has been reported from only one state in the United States where it was described as Clavaurotylenchus (19). This is an obvious synonym of Trophurus.

The picture presented by a summary of the genera occurring on well to excessively drained sands and loamy sands (Table 5) is one that appears to be intermediate between that of the first two groups. On these soils Belonolaimus, Criconemoides, Helicotylenchus, Hoplolaimus, Trichodorus, and Xiphinema are all quite common. Pratylenchus, while not so widespread as in the well-drained sandy loams and loamy sands, is apparently more frequently encountered in this group than in the imperfectly to poorly drained sands. Occurrences of Meloidogyne are also more frequent in this group, although here again more samples of roots from cultivated crops would no doubt show this genus to be much more common than the data presented here indicate.

The absence of Hemicycliophora from this group, as well as from the first group discussed may indicate that species of this genus

are more common in poorly drained, coarse textured soil.

The occurrence of Dolichodorus in five samples from Kanapaha soils is of interest. Soils of this series often are more closely related to the poorly drained group, and the inclusion of this series in the well-drained sands is open to question.

The occurrence of Trophotylenchulus in these soils should also be noted. As stated in the literature the only known species of this genus, T. floridensis, was described by Raski from Florida in 1957 (156). It is apparently fairly common in north central Florida.

The occurrence of plant parasitic genera on several other series is presented in Table 6. The data obtained from samples of muck and marl soils are included in this table for convenience in presentation. Too few samples were obtained for discussion of these results.

In summary, it appears that while there is no obvious correlation of occurrence or non-occurrence of any of the principal plant parasitic nematode genera with any specific soil series, there is an indication that some of the genera may be limited directly or indirectly by soil texture or moisture. These results do show, however, that a more extensive survey conducted over a longer period of time and with due regard for possible effects of host plants on distribution, would be productive of significant findings.

TABLE 1

INTERPRETIVE GROUPING OF SOIL SERIES EXAMINED

1. Well-drained sandy loams and loamy sands:

Carnegie	Ruston
Greenville	Tifton
Norfolk	Faceville
Red Bay	Marlboro

2. Imperfectly to poorly drained sands and loamy sands:

Arzell	Ona
Bladen	Plummer
Immokalee	Rex
Leon	Scranton

3. Poorly to very poorly drained peats and mucks:

Everglades

4. Well to excessively drained sands and loamy sands:

Arredondo	Gainesville
Blanton	Kanapaha
Eustis	Lakeland
Fellowship	Orlando
Fort Meade	

5. Well-drained limestone and poorly drained marls:

Perrine

6. Others:

Alachua	Klej
Archer	St. Johns
Alluvial	

TABLE 2

LIST OF SPECIES WITH SOIL TYPES IN WHICH EACH OCCURRED

Aphelenchus avenae - Arredondo loamy sand, Carnegie loamy fine sand, Kanapaha fine sand, Norfolk loamy fine sand.

Aphelenchoides besseyi - Scranton sand.

Belonolaimus sp. - Alluvial fine sand, Arredondo fine sand, Arzell fine sand, Blanton fine sand, Eustis fine sand, Fellowship fine sand, Gainesville loamy fine sand, Immokalee fine sand, Kanapaha fine sand, Leon fine sand, Lakeland fine sand, Orlando fine sand, Plummer fine sand, Rex fine sand, Scranton sand, St. Johns fine sand.

Belonolaimus longicaudatus - Arredondo fine sand, Norfolk loamy fine sand, Ona fine sand, Scranton fine sand.

Criconemoides sp. - Arredondo fine sand, Bladen fine sand, Fellowship fine sand, Immokalee fine sand, Leon fine sand, Lakeland fine sand, Marlboro fine sandy loam, Plummer fine sand, Red Bay sandy loam, Rex fine sand, Scranton sand, Tifton fine sandy loam.

Criconemoides rusticum - Alachua loamy fine sand, Archer fine sandy loam, Arredondo loamy fine sand, Everglades peaty-muck, Gainesville loamy fine sand, Greenville fine sandy loam, Klej fine sand, Leon fine sand, Norfolk fine sand, Norfolk loamy fine sand, Ona fine sand, Rex loamy fine sand, Ruston fine sandy loam, Scranton fine sand.

Criconemoides cylindricum - Arredondo fine sand, Arredondo loamy

TABLE 2 (Continued)

sand, Arzell fine sand, Carnegie loamy fine sand, Faceville fine sandy loam, Gainesville fine sand, Kanapaha fine sand, Marlboro fine sandy loam, Norfolk fine sand, Norfolk loamy fine sand, Red Bay sandy loam, Ruston fine sandy loam, Scranton fine sand, Tifton loamy fine sand, Tifton fine sandy loam.

Criconemoides mutabile - Fellowship loamy sand, Norfolk fine sand, Norfolk loamy fine sand, Red Bay sandy loam, Scranton fine sand.

Ditylenchus sp. - Archer fine sand, Arredondo fine sand, Arredondo loamy fine sand, Blanton fine sand, Carnegie fine sandy loam, Ft. Meade loamy fine sand, Gainesville loamy fine sand, Kanapaha fine sand, Norfolk loamy fine sand, Red Bay loamy sand, Red Bay sandy loam, Rex loamy fine sand, Ruston fine sandy loam, St. Johns fine sand.

Ditylenchus intermedius - Leon fine sand.

Dolichodorus sp. - Archer fine sand, Arredondo fine sand, Arzell fine sand.

Dolichodorus heterocephalus - Bladen fine sand, Immokalee fine sand, Kanapaha fine sand, Leon fine sand, Ona fine sand, Plummer fine sand, Rex loamy fine sand.

Ecphyadophora tenuissima - Arredondo fine sand, Kanapaha fine sand, Plummer fine sand, Rex loamy fine sand.

TABLE 2 (Continued)

Helicotylenchus sp. - Archer fine sand, Archer loamy fine sand, Arredondo fine sand, Arzell fine sand, Bladen loamy sand, Carnegie loamy fine sand, Fellowship fine sand, Immokalee fine sand, Kanapaha fine sand, Leon fine sand, Lakeland fine sand, Rex loamy fine sand, St. Johns fine sand.

Helicotylenchus nannus - Alachua loamy fine sand, Archer fine sand, Archer loamy fine sand, Arredondo loamy sand, Blanton fine sand, Carnegie loamy fine sand, Carnegie fine sandy loam, Everglades muck, Everglades peaty-muck, Faceville fine sandy loam, Greenville fine sandy loam, Immokalee fine sand, Kanapaha fine sand, Leon fine sand, Marlboro fine sandy loam, Norfolk loamy fine sand, Ona fine sand, Perrine marl, Rex loamy fine sand, Tifton loamy fine sand, Tifton fine sandy loam.

Helicotylenchus erythrinae - Archer loamy fine sand, Carnegie loamy fine sand, Carnegie fine sandy loam, Everglades peaty-muck, Fellowship loamy sand, Ft. Meade loamy sand, Kanapaha fine sand, Ona fine sand, Rex fine sand, Tifton fine sandy loam.

Hemicriconemoides sp. - Arredondo fine sand, Archer fine sand, Arzell fine sand.

Hemicriconemoides wessoni - Blanton fine sand, Archer loamy sand, Ruston fine sandy loam.

TABLE 2 (Continued)

Hemicycliophora sp. - Archer fine sand, Archer loamy fine sand, Arredondo fine sand, Bladen fine sand, Faceville fine sandy loam, Leon fine sand, Plummer fine sand, Rex fine sand, St. Johns fine sand.

Hemicycliophora parvana - Arzell fine sand, Immokalee fine sand.

Hemicycliophora similis - Tifton fine sandy loam.

Hemicycliophora typica - Archer fine sand.

Heterodera sp. - Plummer fine sand.

Hoplolaimus coronatus - Alluvial fine sand, Alachua loamy fine sand, Archer loamy fine sand, Arredondo fine sand, Arredondo loamy fine sand, Arzell fine sand, Bladen fine sand, Blanton fine sand, Carnegie loamy fine sand, Carnegie fine sandy loam, Fellowship fine sand, Fellowship loamy sand, Ft. Meade loamy sand, Immokalee fine sand, Kanapaha fine sand, Klej fine sand, Leon fine sand, Lakeland fine sand, Norfolk fine sand, Norfolk loamy fine sand, Ona fine sand, Perrine Marl, Plummer fine sand, Red Bay loamy sand, Red Bay sandy loam, Rex fine sand, Rex loamy fine sand, Scranton fine sand.

Longidorus sp. - Archer fine sand, Archer loamy sand, Alachua loamy fine sand, Arredondo loamy fine sand, Blanton fine sand, Orlando fine sand.

Longidorus elongatus - Archer fine sandy loam, Kanapaha fine

TABLE 2 (Continued)

sand, Lakeland fine sand, Norfolk fine sand, Red Bay loamy sand, Tifton fine sandy loam.

Meloidodera floridensis - Alluvial fine sand, Lakeland fine sand, Ona fine sand, Plummer fine sand.

Meloidogyne spp. - Alachua loamy fine sand, Archer loamy fine sand, Arredondo fine sand, Arzell fine sand, Everglades muck, Immokalee fine sand, Lakeland fine sand, Norfolk fine sand, Norfolk loamy fine sand, Orlando fine sand, Plummer fine sand, Scranton fine sand.

Meloidogyne hapla - Arredondo fine sand.

Meloidogyne arenaria thamesi - Everglades peaty-muck.

Meloidogyne javanica - Arredondo loamy fine sand, Red Bay sandy loam.

Meloidogyne incognita incognita - Archer loamy fine sand, Leon fine sand.

Meloidogyne incognita acrita - Archer fine sand, Arredondo loamy fine sand, Marlboro fine sandy loam, Rex loamy fine sand.

Paratylenchus spp. - Carnegie fine sandy loam, Tifton fine sandy loam.

Paratylenchus elachistus - Carnegie loamy fine sand.

TABLE 2 (Continued)

Pratylenchus spp. - Arredondo fine sand, Ft. Meade loamy fine sand, Marlboro fine sandy loam, Orlando fine sand.

Pratylenchus brachyurus - Alachua loamy fine sand, Archer loamy fine sand, Arredondo fine sand, Arredondo loamy fine sand, Blanton fine sand, Everglades peaty-muck, Faceville fine sandy loam, Gainesville loamy fine sand, Gainesville, fine sand, Greenville fine sandy loam, Immokalee fine sand, Leon fine sand, Marlboro fine sandy loam, Norfolk fine sand, Norfolk loamy fine sand, Ona fine sand, Red Bay loamy sand, Red Bay sandy loam, Rex fine sand, Rex loamy fine sand, Ruston fine sandy loam, Scranton fine sand, Tifton fine sandy loam.

Pratylenchus penetrans - Arredondo fine sand, Faceville fine sandy loam, Marlboro fine sandy loam, Norfolk fine sand, Norfolk loamy fine sand, Ruston fine sandy loam.

Pratylenchus scribneri - Everglades peaty-muck, Red Bay fine sandy loam.

Pratylenchus zeae - Alluvial sandy clay loam, Archer loamy fine sand, Archer fine sandy loam, Arredondo fine sand, Everglades peaty-muck, Gainesville fine sand, Gainesville loamy sand, Kanapaha fine sand, Klej fine sand, Norfolk fine sand, Norfolk loamy fine sand, Ona fine sand, Red Bay sandy loam, Ruston fine sandy loam, Scranton fine sand, Tifton loamy fine sand.

TABLE 2 (Continued)

Radopholus gracilis (oryzae) - Immokalee fine sand.

Rotylenchulus reniformis - Arredondo fine sand, Norfolk fine sand, Norfolk loamy fine sand.

Scutellonema spp. - Blanton fine sand, Carnegie fine sandy loam, Tifton fine sandy loam.

Scutellonema cohoni - Archer fine sandy loam, Blanton fine sand, Immokalee fine sand, Tifton fine sandy loam.

Scutellonema christiei - Archer fine sand, Archer loamy sand, Blanton fine sand.

Scutellonema brachyurus - Blanton fine sand, Everglades peaty-muck, Kanapaha fine sand.

Sphaeronema sp. - Alluvial fine sand.

Trichodorus spp. - Archer fine sand, Arzell fine sand, Bladen fine sand, Blanton fine sand, Everglades peaty-muck, Faceville fine sandy loam, Immokalee fine sand, Marlboro fine sandy loam, Rex fine sand, Scranton fine sand, St. Johns fine sand.

Trichodorus christiei - Alluvial sandy clay loam, Alachua fine sandy loam, Archer fine sand, Arredondo fine sand, Arredondo loamy fine sand, Arredondo fine sandy loam, Arzell fine sand, Bladen fine sand, Everglades peaty-muck, Ft. Meade loamy fine sand, Immokalee fine sand,

TABLE 2 (Continued)

Ona fine sand, Red Bay sandy loam, Rex fine sand, Ruston fine sandy loam, Scranton fine sand, St. Johns fine sand, Tifton loamy fine sand.

Trichodorus proximus - Archer loamy fine sand, Arredondo fine sand, Bladen fine sandy loam, Blanton fine sand, Fellowship loamy sand, Gainesville fine sand, Greenville fine sandy loam, Immokalee fine sand, Kanapaha fine sand, Marlboro fine sandy loam, Norfolk fine sand, Norfolk loamy fine sand, Red Bay loamy sand, Red Bay sandy loam, Rex loamy fine sand, Tifton loamy fine sand.

Trophotylenchulus floridensis - Alachua loamy fine sand, Arredondo fine sand, Blanton fine sand, Carnegie fine sandy loam, Ft. Meade loamy fine sand.

Tylenchorhynchus spp. - Alachua loamy fine sand, Archer loamy fine sand, Arredondo fine sand, Bladen fine sandy loam, Carnegie loamy fine sand, Immokalee fine sand, Leon fine sand, Perrine marl, Rex loamy fine sand.

Tylenchorhynchus claytoni - Carnegie loamy fine sand, Immokalee fine sand, Tifton fine sandy loam.

Tylenchorhynchus martini - Everglades peaty-muck.

Trophurus sculptus - Rex loamy fine sand.

Tylenchus spp. - Archer fine sand, Arredondo fine sand, Arredondo loamy fine sand, Blanton fine sand, Ft. Meade loamy fine sand, Gainesville loamy fine sand, Leon fine sand, Norfolk fine sand.

TABLE 2 (Continued)

Tylenchus costatus - Alachua loamy fine sand, Carnegie fine sandy loam, Norfolk fine sand, Red Bay fine sand, Ruston fine sandy loam.

Tylenchus minutus - Ruston fine sandy loam.

Xiphinema spp. - Archer fine sand, Archer loamy sand, Archer loamy fine sand, Alachua loamy fine sand, Arredondo fine sand, Arsell fine sand, Blanton fine sand, Carnegie loamy fine sand, Carnegie fine sandy loam, Marlboro fine sandy loam, Norfolk loamy fine sand, Orlando fine sand, Rex loamy fine sand, Scranton sand.

Xiphinema americanum - Alachua loamy fine sand, Archer fine sand, Archer loamy sand, Arredondo loamy sand, Blanton fine sand, Carnegie fine sandy loam, Everglades peaty-muck, Fellowship fine sand, Gainesville fine sand, Immokalee fine sand, Kanapaha fine sand, Lakeland fine sand, Norfolk loamy fine sand, Norfolk fine sand, Ona fine sand, Red Bay loamy sand, Red Bay sandy loam, Rex fine sand, Scranton fine sand, Tifton loamy fine sand, Tifton fine sandy loam.

Xiphinema longicaudatus - Alachua loamy fine sand, Ft. Meade loamy fine sand, Gainesville loamy fine sand.

Xiphinema radicicola - Arsell fine sand.

Xiphinema diversicaudatum - Everglades peat.

Xiphinemella sp. - Tifton fine sandy loam.

TABLE 3

OCCURRENCE OF NEMATODES IN SOME WELL-DRAINED SANDY LOAMS AND LOAMY SANDS

Genus	Number of Samples in Which Identified							
	A[a]	B	C	D	E	F	G	H
	3[b]	1	31	70	4	9	1	41
Aphelenchoides	-	-	-	-	-	-	-	-
Aphelenchus	1	-	1	-	-	-	-	-
Belonolaimus	-	-	2	-	-	-	-	-
Criconemoides	1	1	28	57	4	8	1	9
Ditylenchus	1	-	2	3	1	-	-	-
Dolichodorus	-	-	-	-	-	-	-	-
Ecphyadophora	-	-	-	-	-	-	-	-
Helicotylenchus	3	1	1	-	-	7	1	37
Hemicriconomoides	-	-	-	-	1	-	-	-
Hemicycliophora	-	-	-	-	-	1	1	-
Hoplolaimus	3	-	4	2	-	1	-	-
Longidorus	-	-	2	1	-	1	-	-
Meloidodera	-	-	-	-	-	-	-	-
Meloidogyne	-	-	1	1	-	-	-	2
Paratylenchus	2	-	-	-	-	1	-	-
Pratylenchus	1	1	31	66	3	6	1	11
Radopholus	-	-	-	-	-	-	-	-
Rotylenchulus	-	-	3	-	-	-	-	-
Scutellonema	-	-	-	-	-	-	-	-
Sphaeronema	-	-	-	-	-	-	-	-
Trichodorus	-	1	26	56	2	8	1	5
Trophotylenchulus	1	-	-	-	-	-	-	-
Trophurus	-	-	-	-	-	-	-	-
Tylenchorhynchus	2	-	-	-	-	1	-	-
Tylenchus	1	-	1	3	1	-	-	-
Xiphinema	3	-	12	23	1	4	-	2
Xiphinemella	-	-	1	-	-	-	-	-

[a]A - Carnegie, B - Greenville, C - Norfolk, D - Red Bay, E - Ruston, F - Tifton, G - Faceville, H - Marlboro.

[b]Total number of samples from the series.

TABLE 4

OCCURRENCE OF NEMATODES IN SOME IMPERFECTLY TO POORLY DRAINED SANDS AND LOAMY SANDS

Genus	Number of Samples in Which Identified							
	A[a]	B	C	D	E	F	G	H
	6[b]	3	3	28	18	2	7	4
Aphelenchoides	-	-	-	-	-	-	-	1
Aphelenchus	-	-	-	-	-	-	-	-
Belonolaimus	2	1	1	10	5	1	1	2
Criconemoides	1	-	1	14	2	1	2	4
Ditylenchus	-	-	-	1	-	-	1	-
Dolichodorus	1	-	3	1	1	1	1	-
Ecphyadophora	-	-	-	-	-	1	1	-
Helicotylenchus	1	2	1	24	8	-	3	-
Hemicriconemoides	1	-	-	-	-	-	-	-
Hemicycliophora	1	1	2	6	1	1	1	-
Hoplolaimus	4	-	1	24	11	2	4	2
Longidorus	-	-	-	-	-	-	-	-
Meloidodera	-	-	-	-	4	1	-	-
Meloidogyne	1	-	1	-	-	1	1	1
Paratylenchus	-	-	-	-	-	-	-	-
Pratylenchus	-	-	1	4	4	-	2	2
Radopholus	-	-	1	-	-	-	-	-
Rotylenchulus	-	-	-	-	-	-	-	-
Scutellonema	-	-	2	-	-	-	-	-
Sphaeronema	-	-	-	-	-	-	-	-
Trichodorus	2	2	2	3	10	-	6	2
Trophotylenchulus	-	-	-	-	-	-	-	-
Trophurus	-	-	-	-	-	-	2	-
Tylenchorhynchus	-	1	1	13	-	-	2	-
Tylenchus	-	-	-	1	-	-	-	-
Xiphinema	3	-	1	-	4	-	2	3
Xiphinemella	-	-	-	-	-	-	-	-

[a] A - Arsell, B - Bladen, C - Immokalee, D - Leon, E - Ona, F - Plummer, G - Rex, H - Scranton.

[b] Total number of samples from the series.

TABLE 5

OCCURRENCE OF NEMATODES IN SOME WELL TO EXCESSIVELY DRAINED SANDS AND LOAMY SANDS

Genus	Number of Samples in Which Identified								
	A[a]	B	C	D	E	F	G	H	I
	61[b]	5	2	16	4	7	16	5	1
Aphelenchoides	-	-	-	-	-	-	-	-	-
Aphelenchus	3	-	-	-	-	1	3	-	-
Belonolaimus	25	1	2	14	-	-	2	2	1
Criconemoides	15	1	-	16	-	4	1	2	-
Ditylenchus	3	1	-	-	2	2	1	-	-
Dolichodorus	-	-	-	-	-	-	5	-	-
Ecphyadophora	2	-	-	-	-	-	2	-	-
Helicotylenchus	9	1	-	11	1	2	5	1	-
Hemicriconemoides	-	1	-	-	-	-	-	-	-
Hemicycliophora	-	-	-	-	-	-	-	-	-
Hoplolaimus	6	1	-	13	1	1	6	1	-
Longidorus	3	1	-	-	-	1	1	1	1
Meloidodera	-	-	-	-	-	-	-	1	-
Meloidogyne	10	-	-	-	-	1	-	1	1
Paratylenchus	-	-	-	-	-	-	-	-	-
Pratylenchus	24	1	-	-	1	5	3	-	1
Radopholus	-	-	-	-	-	-	-	-	-
Rotylenchulus	-	-	-	-	-	-	-	-	-
Scutellonema	-	3	-	-	-	-	1	-	-
Sphaeronema	-	-	-	-	-	-	-	-	-
Trichodorus	23	3	-	1	2	4	7	3	-
Trophotylenchulus	18	2	-	-	2	1	-	-	-
Trophurus	-	-	-	-	-	-	-	-	-
Tylenchorhynchus	-	-	-	-	-	1	-	-	-
Tylenchus	3	1	-	-	2	-	-	-	-
Xiphinema	23	5	1	7	1	6	2	4	1
Xiphinemella	-	-	-	-	-	-	-	-	-

[a] A - Arredondo, B - Blanton, C - Eustis, D - Fellowship, E - Ft. Meade, F - Gainesville, G - Kanahapa, H - Lakeland, I - Orlando.

[b] Total number of samples from the series.

TABLE 6

OCCURRENCE OF NEMATODES IN OTHER SOILS INCLUDING POORLY DRAINED MUCK AND MARL

Genus	Number of Samples in Which Identified						
	A[a]	B	C	D	E	F	G
	2[b]	7	2	1	1	6	7
Aphelenchoides	-	-	-	-	-	-	-
Aphelenchus	-	-	-	-	-	-	-
Belonolaimus	-	-	1	-	1	-	-
Criconemoides	2	1	-	1	-	-	-
Ditylenchus	-	1	-	-	-	-	-
Dolichodorus	-	1	-	-	1	-	-
Ecphyadophora	-	-	-	-	-	-	-
Helicotylenchus	1	5	-	-	1	6	4
Hemicriconemoides	-	1	-	-	-	-	-
Hemicycliophora	-	2	-	-	1	-	-
Hoplolaimus	1	2	1	1	-	1	-
Longidorus	-	4	-	-	-	-	-
Meloidodera	-	-	1	-	-	-	-
Meloidogyne	2	3	-	-	-	-	-
Paratylenchus	-	-	-	-	-	-	-
Pratylenchus	1	5	1	1	-	-	3
Radopholus	-	-	-	-	-	-	-
Rotylenchulus	-	-	-	-	-	-	-
Scutellonema	-	4	-	-	-	-	1
Sphaeronema	-	-	1	-	-	-	-
Trichodorus	1	3	1	1	1	-	2
Trophotylenchulus	-	-	-	-	-	-	-
Trophurus	-	-	-	-	-	-	-
Tylenchorhynchus	1	1	-	-	-	1	2
Tylenchus	1	1	-	-	-	-	-
Xiphinema	2	2	-	-	-	-	1
Xiphinemella	-	-	-	-	-	-	-

[a] A - Alachua, B - Archer, C - Alluvial, D - Klej, E - St. Johns, F - Perrine Marl, G - Everglades Peaty-Muck.

[b] Total number of samples from the series.

Effects of Soil Texture on Occurrence.

Results of the survey of the soil series presented above indicated the possibility of direct or indirect effect of soil texture on occurrence of one or more of the genera found. In order to examine this possibility data from the samples were grouped to show the percent occurrence of the principal genera in samples from soils of three textural classes: sands, loamy sands, and sandy loams. These data are shown in Table 7.

Several points of interest are apparent in this presentation. Specimens of Belonolaimus were found in 41 percent of the samples from sandy soils, but in only 5 percent of those from loamy sands, and in none from sandy loams. This appears consistent with observations that nematodes of this genus are more common on coarser textured soils (37). These results may indicate that species of Belonolaimus are restricted to such soils. This possibility was tested experimentally as a part of these investigations and the results obtained are reported in another section of this presentation.

Specimens of Hoplolaimus also appeared to show a distribution affected by soil texture. As mentioned above this result is not in accord with that reported by Jenkins et al. (99) in Maryland. This difference may be more apparent than real. It is possible that more extensive sampling of grasses from loamy sands and sandy loams is indicated.

Occurrence of species of Criconemoides was twice as frequent in loamy sands and sandy loams as in sands. Species of Xiphinema were twice as frequent in loamy sands as in sands or sandy loams. These

observations warrant further investigation.

The most common genera found in sands, in order of their percent occurrence, were: Hoplolaimus, Belonolaimus, Helicotylenchus, Trichodorus, Criconemoides, Xiphinema, and Pratylenchus. For loamy sands the order was: Pratylenchus, Trichodorus, Criconemoides, Xiphinema, Helicotylenchus, and Hoplolaimus. Six other genera were more frequently encountered than was Belonolaimus. On the sandy loams the order of occurrence was: Pratylenchus, Criconemoides, Trichodorus, Helicotylenchus, and Xiphinema.

In order to test the reliability of the findings, the results of a number of determinations of samples submitted by county agents and growers from 39 counties in the state were summarized in Table 8. The number of samples examined from each county together with the genera found are listed in Table G in the Appendix.

While the soil series from which these samples were taken was not known, the texture was determined in the laboratory. A total of 393 samples of sands and fine sands was examined. Data from the very small number of samples of finer textured soils were not included. The frequency of occurrence of the genera in these samples was: Hoplolaimus, Belonolaimus, Criconemoides, Trichodorus, Helicotylenchus, Pratylenchus, and Xiphinema. The percent occurrence of Belonolaimus, Criconemoides, and Trichodorus was substantially in agreement with that for the sands presented in Table 7. The occurrence of Helicotylenchus, Xiphinema, and Pratylenchus was found to be less in the samples recorded in Table 8 than in those from the sands recorded in Table 7.

TABLE 7

OCCURRENCE OF PLANT PARASITIC NEMATODES IN SOME SAMPLES OF SANDS, LOAMY SANDS, AND SANDY LOAMS FROM FLORIDA

Genus	Percent Occurrence		
	Sands[a]	Loamy Sands[a]	Sandy Loams[a]
Belonolaimus	41.0	5.0	0.0
Criconemoides	33.6	63.6	59.4
Ditylenchus	4.0	12.5	1.8
Dolichodorus	8.5	1.3	0.9
Helicotylenchus	37.6	25.0	36.6
Hemicycliophora	10.2	1.3	1.8
Hoplolaimus	43.3	18.8	1.8
Longidorus	5.1	8.8	0.0
Meloidogyne	8.5	7.5	2.7
Pratylenchus	24.4	67.3	70.0
Trichodorus	37.0	65.0	55.0
Trophotylenchulus	11.9	6.3	0.0
Tylenchorhynchus	7.9	8.8	0.9
Tylenchus	2.9	8.8	1.8
Xiphinema	28.4	45.0	20.4

[a]Total samples examined: sands - 176, loamy sands - 80, sandy loams - 113.

TABLE 8

OCCURRENCE OF PLANT PARASITIC NEMATODE GENERA IN SAMPLES OF SANDS AND FINE SANDS FROM 39 FLORIDA COUNTIES

	Occurrence		
	Number of Counties	Number Samples in Which Found	Percent of Total Samples[a]
Belonolaimus	27	163	41.5
Criconemoides	27	145	37.0
Ditylenchus	1	2	0.5
Dolichodorus	3	3	0.8
Helicotylenchus	19	74	18.8
Hemicriconemoides	5	17	4.3
Hemicycliophora	11	30	7.6
Heterodera	2	2	0.5
Hoplolaimus	27	206	52.5
Longidorus	3	7	1.8
Meloidogyne	10	20	5.1
Pratylenchus	13	41	10.8
Scutellonema	3	3	0.8
Trichodorus	24	116	29.5
Tylenchorhynchus	6	10	2.5
Xiphinema	19	38	9.7

[a]Total samples examined - 393.

Presence of Nematodes in Uncultivated Soils.

The methods by which nematodes may be transported from one site to another include flood waters, lateral drainage, wind, animals, and by man in vehicles or cultivation equipment, or in transplanted shrubs or other plants. There is always the possibility that one or more of these methods has served to transport nematodes from cultivated areas to uncultivated sites. Therefore it would be pure speculation to assert that this or that species was native to an area on the basis of examination of soils from uncultivated areas.

It is important to know, however, as may be seen from the list of nematodes found in uncultivated soils (Table 9), that at least 30 species of the most common plant parasitic nematodes known in Florida may be found in soils not in cultivation. The practical significance of this finding to agriculture is that no site may be considered to be free from plant parasitic nematodes merely because it has never been taken into cultivation. True, the level of infestation is much lower in uncultivated soils, but the apparent ubiquity of most plant parasitic nematodes means that under favorable conditions an economically significant level of population may be built up by one or more nematodes without introducing them from cultivated sites.

Uncultivated sites at one or more locations on the following soils series were sampled for plant parasitic nematodes: Carnegie, Norfolk, Red Bay, Ruston, Tifton, Leon, Ona, Plummer, Rex, Everglades, Arredondo, Blanton, Fellowship, Fort Meade, Gainesville, Kanapaha, Lakeland, Archer, and two textures of alluvial soils. The percent

occurrence of genera in samples from these sites is presented in Table 10. A comparison of these percentages with those obtained for the percent occurrence of genera in the 762 samples examined from all sources shows the following: Percent occurrence of Belonolaimus in all samples, 30.8, in samples from uncultivated sites, 16.0; percent occurrence of Criconemoides in all samples, 41.3, in those from uncultivated soils, 25.3; percent occurrence of Helicotylenchus in all samples, 26.4, in those from uncultivated soils, 36.0. The respective figures for Pratylenchus are 28.5 and 22.6; for Trichodorus they are 38.5 and 45.3; and for Xiphinema they are 21.2 and 56.0. Species of Meloidogyne were found in 5.8 percent of all samples examined and in 8.0 percent of those from uncultivated soils.

These figures indicate clearly that plant parasitic nematodes are as frequently encountered in uncultivated as in cultivated soils.

Summary and Conclusions

A total of 762 soil samples were processed and the plant parasitic nematodes found were determined to genus or to species. Of these samples 369 were obtained from 106 sites on 31 soil series. The remaining 393 samples were obtained from sands and fine sands of 39 counties in the state.

No conclusion could be reached as to the value of the soil series as a mapping unit which might serve to indicate the presence or absence of species of plant parasitic nematodes.

The data obtained indicate that soil associations, or groups of soil series, may prove of value as indicators of presence or absence of

certain species. A more intensive investigation of this possibility appears warranted.

The data also support the hypothesis that at least one genus, Belonolaimus, is limited in its distribution by soil texture. Experiments to test the possibility that population levels of Hoplolaimus, Pratylenchus and Xiphinema may also be affected by soil texture seem worthwhile.

These investigations have established that most of the common plant parasitic nematodes of Florida are present in both cultivated and uncultivated soils. However, it appears that they are present in fewer numbers in the latter. It would be most fruitful, from the standpoint of future cultural practices, to determine why this is true.

TABLE 9

LIST OF PLANT PARASITIC NEMATODES FOUND IN UNCULTIVATED SOILS

Aphelenchus avenae	Paratylenchus sp.
Belonolaimus sp.	Paratylenchus elachistus
Belonolaimus longicaudatus	Pratylenchus brachyurus
Criconemoides cylindricum	Pratylenchus zeae
Criconemoides mutabile	Rotylenchulus reniformis
Criconemoides rusticum	Sphaeronema sp.
Ditylenchus sp.	Scutellonema sp.
Dolichodorus heterocephatus	Scutellonema brachyurus
Helicotylenchus erythrinae	Scutellonema christiei
Hemicriconemoides nessoni	Trichodorus christiei
Hemicycliophora sp.	Trichodorus proximus
Hemicycliophora similis	Trophotylenchulus floridensis
Hemicycliophora typica	Tropburus sculptus
Hoplolaimus coronatus	Tylenchorhynchus sp.
Hoplolaimus gadadenensis	Tylenchorhynchus claytoni
Longidorella sp.	Tylenchus costatus
Longidorus sp.	Tylenchus minutus
Longidorus elongatus	Xiphinema americanum
Meloidodera floridensis	Xiphinema longicandatus
Meloidogyne incognita acrita	Xiphinemella sp.

TABLE 10

OCCURRENCE OF PLANT PARASITIC NEMATODES IN SOIL SAMPLES FROM UNCULTIVATED SITES[a]

Genera	Number Samples in Which Found	Percent of Total Samples
Aphelenchus	3	4.0
Belonolaimus	12	16.0
Criconemoides	19	25.3
Ditylenchus	11	14.7
Dolichodorus	5	6.8
Helicotylenchus	27	36.0
Hemicriconemoides	3	4.0
Hemicycliophora	7	9.3
Hoplolaimus	24	32.0
Longidorus	14	18.6
Meloidodera	7	9.3
Meloidogyne	6	8.0
Paratylenchus	4	5.3
Pratylenchus	17	22.6
Rotylenchulus	2	2.7
Scutellonema	7	9.3
Sphaeronema	1	1.4
Trichodorus	34	45.3
Trophotylenchulus	25	33.3
Tylenchorhynchus	6	8.0
Trophurus	2	2.6
Tylenchus	9	12.0
Xiphinema	42	56.0
Xiphinemella	1	1.4

[a]Total sites examined - 35; total samples - 75.

SURVIVAL OF BELONOLAIMUS LONGICAUDATUS IN DIFFERENT SOILS

The data obtained in this survey indicate the possibility of a direct effect of soil texture on the occurrence of Belonolaimus spp. in mineral soils. In addition, observations by others (35) show that these nematodes may not be able to survive in muck and marl soils.

The ability of Belonolaimus longicaudatus to survive in mineral soils of different clay content and in a muck and a marl soil was tested in a greenhouse experiment.

Methods and Procedure

Preparation of Soils.

Quantities of an Arredondo subsoil and of a Greenville subsoil were obtained. These were air-dried and sieved through a one millimeter sieve. The percent sand, silt, and clay was then determined for each soil by the Boyoucos hydrometer method. On the basis of these determinations mixtures of the two soils were made to provide soils containing approximately 15 and 30 percent by weight of clay. The actual percentage of sand, silt, and clay in the mixtures was verified at the conclusion of the experiment by the Boyoucos method.

Samples of Everglades peaty muck and Flamingo silty clay were also used in the experiments. These were not dried since dry muck is difficult to re-wet and the Flamingo clay dries into hard lumps. Samples of both, processed by the Christie-Perry technique, showed no

plant parasitic nematodes to be present. Percent sand, silt, and clay in the Flamingo soil was determined by the Boyoucos method. None of the soils used in the trials were sterilized.

Six-inch clay pots set in clay saucers were used. These were filled to within one inch of the top with the muck and marl soils, and with 1500 grams (air dry basis) of the mineral soils and the two mineral soil mixtures. The soil in the pots was leached by filling the pots to the top with demineralized water every day for one week. This was done in order to settle the soils in an approximation of field conditions. The pots were then watered from below by placing demineralized water in the saucers to maintain the soils in a moist condition until used.

Seven to ten days before inoculation with nematodes four seeds of Dixie Hybrid sweet corn were planted in each pot. The pots were inoculated when seedlings were from two to three inches high, after thinning to two plants per pot.

Collection of Nematodes.

Specimens of Belonolaimus sp. in sufficient quantities for the experiment were obtained from an infested corn field at the Agronomy Farm, Florida Agricultural Experiment Station.

The nematodes were collected by digging up the entire root system of a corn plant in a ball of soil about one cubic foot in volume. The outer portion of the ball was removed until about half the initial bulk remained about the roots. This remaining soil was then vigorously washed off by plunging the plant up and down in a bucket half full of

water. After this thorough washing the roots were discarded and the soil suspension in the bucket carried to the laboratory where the nematodes were extracted by the Christie-Perry technique. A number of funnels were used to avoid overloading them with soil.

At the end of 24 hours five milliliters of water containing the nematodes was drawn off into a Syracuse watch glass from which specimens of Belonolaimus were picked by hand. Twenty specimens picked at random were determined to species and all were found to be Belonolaimus longicaudatus.

Procedure.

Twenty four pots were arranged in a random block design of six treatments and four replicates on a greenhouse bench.

The six treatments were as follows:

1. Arredondo subsoil
2. Mixed soil containing 15 percent clay
3. Mixed soil containing 30 percent clay
4. Greenville subsoil
5. Everglades peaty muck
6. Flamingo silty clay

Corn seeds were planted in the pots on October 1, 1958, and specimens of Belonolaimus longicaudatus added on October 9 and 10.

Each of the clay pots was inoculated with 100 females and 10 males by making a dowel hole to a depth of two inches in the center of the pot into which the nematodes were washed from a small vial. The hole was then covered and the pots watered from below. All nematodes

were placed in pots within 72 hours after collection in the field.

The trial was terminated on November 28, 1958. The soil in each pot was processed by the Seinhorst elutriator technique, with the following modifications: at the completion of elutriation as outlined by Seinhorst (166) the suspensions containing nematodes were drawn off from outlets C_1, C_2, and D_2 into a 10-quart plastic bucket. This liquid was poured over a pair of nested 325 mesh sieves which were supported over a second plastic bucket by a wire rack. These sieves were separated and the nematodes retained on the mesh were washed into a beaker, using a small volume of water. Each sieve having been so washed, they were placed over the first bucket and the suspension from the second bucket again poured over them. When the nematodes on the sieves had again been washed into the beaker the contents of the beaker--nematodes in about 50 ml. of water--were poured gently onto the cloth of the Baermann funnel in the same way as in the Christie-Perry procedure.

This modification is not proposed as an improvement in Seinhorst's procedure. It was used because the nest of five to seven sieves of 50 micron size required for his procedure was not available.

At the end of 24 hours the cloth and its supporting ring was removed from the funnel, the entire contents of the funnel drawn off through a 325 mesh sieve three inches in diameter, and the funnel walls washed down to collect any adhering nematodes. The funnel was then filled with fresh water, the cloth and contents replaced, and allowed to stand another 24 hours when the process was repeated. The nematodes collected at the end of each 24-hour period were counted. On the tenth

day, when specimens of Belonolaimus were no longer recovered from any funnel, the debris on the cloth was sampled and searched under the stereoscopic microscope to determine whether any nematodes were left on the cloth.

This rather laborious procedure was considered necessary to insure that none of the nematodes were retained in the debris. It was concluded, after finding only one specimen in a 15 milliliter volume sample of debris from a single replicate of Greenville clay soil, that no appreciable numbers of Belonolaimus were so retained.

Results and Discussion

The average number of Belonolaimus longicaudatus recovered from the four replicates of each treatment, together with the percent sand, silt, and clay, are presented in Table 11. Recovery from each replicate is shown in the Appendix (Table H).

The numbers of Belonolaimus longicaudatus recovered in this experiment are belived to be a reflection of the ability of these nematodes to survive and reproduce in the soils and soil mixtures used.

It is considered that, for the five mineral soils used, there is a direct effect of soil texture on the ability of Belonolaimus longicaudatus to survive. These nematodes are ectoparasites. Observations on the feeding habits of these nematodes on corn roots in agar show that they are vagrant parasites. That is, they feed for a time near a root tip and then leave it to wander through the agar, returning after a period to the same or another root tip. They were

not observed to feed at any distance greater than one half inch from root tips. The feeding of these nematodes causes severe injury to root tips (37), therefore it is considered necessary for them to move from damaged root tips to undamaged ones during their period of development.

These observations support the hypothesis that, for this species of nematode, movement in soil is necessary for survival. Wallace (208, 209) has shown that there is a relationship between particle size and optimum conditions for movement of at least two species of nematodes, and further that there is a direct relationship between particle size and length and the rate of movement in the two species he studied. The longer of those two nematodes moved faster in soil separates of large particle size than in those of small particle size. In addition Wallace (208) has shown that nematodes do not burrow or displace soil particles. They move through pores.

Conclusions

From a consideration of the feeding habits of Belonolaimus longicaudatus together with the results of this trial, as well as the observations and experiments of Wallace, it is considered that the distribution of Belonolaimus longicaudatus is limited by soil texture and that these nematodes are unlikely to build up large populations on soils of textures finer than fine sandy loams.

The effect of Everglades peaty-muck on populations of Belonolaimus sp. is not necessarily one of restriction of movement, although this may well be the case. Johnston (101) has shown that under

anaerobic conditions species of Clostridium may produce a toxin in sufficient quantities to kill nematodes. The operation of such a factor was not precluded here since the soils were not sterilized and the nematodes added to them were not treated to remove bacteria.

TABLE 11

AVERAGE NUMBER OF BELONOLAIMUS LONGICAUDATUS RECOVERED FROM SURVIVAL EXPERIMENT

Treatment Number	Soil	Number of Belonolaimus[a]	Percent		
			Sand	Silt	Clay
1.	Arredondo subsoil	322.2	93.4	3.4	3.2
2.	Mixed soil, 15 percent clay	52.5	80.8	4.5	14.7
3.	Mixed soil, 30 percent clay	15.0	60.4	10.4	29.2
4.	Greenville subsoil	9.1	47.6	11.2	41.2
5.	Everglades peaty-muck	16.7	-	-	-
6.	Flamingo silty-clay	0.5	6.4	51.4	42.2
	Significant Difference (Tukey's D - 19:1)	50.3			

DESCRIPTION OF A NEW SPECIES OF HOPLOLAIMUS

During the course of this survey the following undescribed species, herewith named Hoplolaimus gadsdenensis n.sp., was obtained from soil samples taken from an apparently undisturbed tract of pine woodland. It is described herewith as follows:

Dimensions.

Ten females. Length = .710 - .916 mm. (mean, .807 mm.); a = 26 - 29 (mean, 27); b = 5.0 - 6.5 (mean, 5.5); c = 48 - 75 (mean, 64.4); V = 53 - 59% (mean, 56.4%).

Three males. Length = .715 - .791 mm.; a = 31 - 33; b = 5.2 - 5.8; c = 39 - 47.

All measurements were made on living specimens mounted in tap water. The ratio "b" was determined by dividing the total length by the distance from the head to the end of the esophagal glands, rather than to the junction of esophagus and intestine.

Female.

Head height, 4.1 - 5.0 u;* width, 8.1 - 9.0 u, set off from body by slight constriction. Bears about four indistinct annules of which the basal is widest. Basal annule with 13 or more faint longitudinal divisions, appearing as crenulations when seen en face (Fig. 1-G).

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*u (micron).

Six distinct lips, apparently with full complement of papillae. Lateral lips with faint slit-like amphidial opening. Internal sclerotization heavy, resembling H. proporicus, Goodey, 1957 (76).

Body approximately cylindrical posterior to latitude of esophagal glands, tapering anteriorly to constriction at head (Fig. 1-A). Mean diameter at constriction 8.9 μ, at median bulb 22.7 μ, near vulva 30 μ. Body assumes open spiral when fixed by gentle heat. Tail short, usually hemispherical in outline, from 9.5 to 17.5 μ long. Lateral field from 4.2 to 7.2 μ wide, very distinct. Three incisures in field from base of stylet to point just posterior to median bulb where middle incisure divides. Four incisures extend from this latitude to terminus (Fig. 1-B). Transverse striae crossing all incisures from their origin to point where inner incisure divides, thence crossing at irregular intervals to latitude of distal end of esophagal glands; completely interrupted at outer incisures from this latitude posteriorad except for four to eight striae crossing outer incisures at each scutellum (Fig. 1-C). Width of annules from 1.6 to 2.3 μ on outer cuticle. No deirids seen. Phasmids large, scutellar shaped, not opposite. Either left or right scutellum may be anterior. Position of anterior scutellum varying from 28 to 44 percent of body length (mean, 38 percent), position of posterior scutellum varying from 77 to 88 percent (mean, 82 percent).

Stylet strongly developed 29 - 34 μ long (mean, 30.8), length of fore part 13 - 16 μ, average shaft diameter 2.3 μ; knobs broadly rounded posteriorly, truncate anteriorly, not tulip shaped; anterior

margin with single minute projection. Average width of knobs 5.5 u, average length 3.7 u. Stylet muscles large, extending to skeletal framework of head. Dorsal gland orifice opening from 3.6 to 5 u behind knobs of stylet.

Terminal portion of excretory duct extending through a cone-shaped inward projection of hypodermis, clearly visible in living specimens, appearing as indistinct dilation of duct in fixed material. Excretory pore opening on ventral surface from 103 to 117 u (mean, 112) posterior to head. Hemizonid present, usually about two annules anterior to excretory pore, often arcuate, from 2 to 4 u long.

Reproductive system appears more or less developed depending on age of female after last molt. Ovaries paired, approximately equal, outstretched in more mature specimens, with flexure at junction to spermatheca in less mature females. Tip of anterior ovary extending an average distance of 168 u from vulva, tip of posterior ovary about 160 u posterior to vulva. Spermatheca distinct, subspherical (17.5 u long by 15.5 u wide) in mature forms, more elongate and narrower in those less mature. Anterior spermathecum from 41 to 77 u (mean, 59 u) anterior to vulva, posterior spermathecum from 58 to 87 u (mean, 66 u) posterior to vulva. Internal appearance of spermatheca variable depending on maturity. Occasionally contain several small spherical bodies which may be spermatozoa; often with from three to seven elongate, spindle-shaped bodies. No completely developed eggs seen in any specimens. Vagina elongate with relatively thin walls. Vulva a transverse slit with inward projecting sclerotization; without protruding lips.

Male.

Similar to female except for smaller size. Testis single, outstretched. Bursa enveloping tail. Spicules ventrally curved, with broad, very thin, lateral flanges; approximately 30 μ long. Gubernaculum cephalated, 13 - 15 μ long, with a single pair of titillae at tip (Fig. 1-D). Telamon not seen. Ratio of one male to 25 females in two collections.

Larvae.

Varying in length from 320 to 640 μ (n = 7). Anterior scutellum located at 56 percent in a specimen 320 μ long, at 51 percent in a specimen 490 μ long, and at 46 percent in one 640 μ long. A single specimen 492 μ long was observed to have neither phasmid nor scutellum, although the entire length of the lateral field on both sides was distinctly visible. The latitude of the posterior scutellum varies only slightly with differences in body length, i.e., from 87 percent in a larva 320 μ long to 85 percent in one 640 μ long.

Type habitat: Soil around roots of wiregrass, Aristida stricta Michx., in high pine associes.

Type locality: Gadsden County, Florida. Northwest quarter of northeast quarter of section 21, Range 4 West, Township 3 North, in Carnegie loamy fine sand.

Type specimens: Holotype female in tray 1, Cabinet E-368, Department of Entomology, Agricultural Experiment Station, Gainesville. Allotype male, the single whole specimen on slide so

labeled in same location as female. Paratypes deposited in collection of the Department of Plant Nematology, University of California, Berkeley.

Diagnosis.

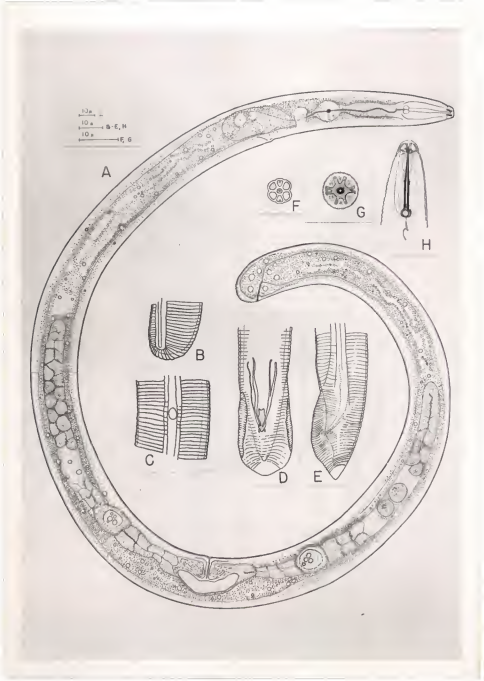
Hoplolaimus gadsdenensis n.sp. most closely resembles H. proporicus Goodey, 1957, and Scutellonema christiei (Golden and Taylor, 1956) Andrassy, 1958. From the former it may be separated by the presence of four distinct lateral lines and from the latter by the four lateral lines, the position of the scutellar shaped phasmids, presence of crenulations on the outline of the basal head annule when viewed en face, presence of titillae on the gubernaculum of the male, and absence of protruding lips on the vulva of the female.

Discussion.

This species cannot be placed in any of the genera of Hoplolaiminae as characterized by Andrassy (8) in his recent treatment of the subfamily without emendation of one or more of them. Such emendation is not considered advisable without thorough study of all the known forms. Since this new species more closely resembles Hoplolaimus proporicus than Scutellonema christiei it is considered to be congeneric with the former and is therefore placed in the genus Hoplolaimus.

FIGURE 1. Hoplolaimus gadsdenensis n. sp.

A. - Female. B. - Female tail showing lateral field. C. - Scutellum. Note transverse striae crossing outer incisures. D. - Male tail, ventral view, showing gubernaculum with titillae. E. - Male tail, lateral view. F. - Lip region of female. G. - En face view of female head. Note crenulation of outline of basal annule. H. - Anterior region of female.


A
B
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H

APPENDIX

TABLES

TABLE A

NEMATODES FOUND IN WELL-DRAINED SANDY LOAMS AND LOAMY SANDS[a]

A-1. Carnegie Series. Site No. 1 Uncultivated. July 17, 1958.

Location: Gadsden Co., Fla. NW 1/4 of NE 1/4 Sect. 21, R4W, T3N.

Vegetation: Longleaf pine, slash pine, wiregrass, palmetto, huckleberry, *Vicia* sp.

Depth of Samples:	0 - 4 in.	4 - 10 in.	10 - 20 in.
Texture:	loamy sand	sandy loam	sandy clay loam
Percent sand:	76.8	76.6	65.4
silt:	18.0	14.0	13.2
clay:	5.2	9.4	21.4
pH.	5.5	5.5	5.3
Nematodes Found:			
Aphelenchus avenae	+	-	-
Criconemoides ornatum	+	+	-
Helicotylenchus erythrinae	+	-	+
Hoplolaimus coronatus	-	+	+
Hoplolaimus gadadenensis	+	+	+
Paratylenchus sp.	+	-	-
Paratylenchus elachistus	+	-	-
Tylenchorhynchus claytoni	-	+	-
Xiphinema americanum	+	-	-

[a]One sample per site or depth unless stated otherwise.

TABLE A (Continued)

A-2. Carnegie Series. Site No. 1 Uncultivated. August 22, 1958.

Location: Gadsden Co., Fla. NW 1/4 of NE 1/4 Sect. 21, R4W, T3N.

Vegetation: Longleaf pine, slash pine, wiregrass, palmetto, huckleberry, *Vicia* sp.

Depth of Samples:	0 - 4 in.	4 - 10 in.
Texture:	loamy sand	sandy loam
Percent sand:	76.8	76.6
silt:	18.0	14.0
clay:	5.2	9.4
pH.	5.5	5.5
Nematodes Found:		
Ditylenchus sp.	+	-
Helicotylenchus erythrinae	-	+
Hoplolaimus coronatus	+	+
Hoplolaimus gadsdenensis	+	-
Pratylenchus zeae	+	-
Trophotylenchulus floridensis	+	-
Tylenchus costatus	-	-
Xiphinema americanum	+	+

TABLE A (Continued)

A-3. Carnegie Series. Site No. 1 Uncultivated. August 22, 1958.

Location: Same as A-2.

Vegetation: Wiregrass, Vicia sp.

Depth of Sample: 0 - 6 in.

Texture: sandy loam

Nematodes Found:

Helicotylenchus nannus
Hoplolaimus coronatus
Hoplolaimus gadsdenensis
Paratylenchus sp.
Tylenchorhynchus sp.
Xiphinema americanum

B-1. Greenville Series. Site No. 1 Cultivated. May 11, 1958.

Location: Jefferson Co., Fla. SE 1/4 of NE 1/4 Sect. 1, R4E, T2N.

Vegetation: Fallow.

Depth of Sample: 2 - 8 in. (upper 2 in. eroded)

Texture: sandy loam

Percent sand: 80.0

silt: 7.5

clay: 12.5

Nematodes Found:

Criconemoides rusticum
Helicotylenchus nannus
Pratylenchus brachyurus
Trichodorus proximus

TABLE A (Continued)

C-1. Norfolk Series. Site No. 1 Uncultivated. August 22, 1958.

Location: Gadsden Co., Fla. SW 1/4 of SE 1/4 Sect. 8, R2W, T2N.

Vegetation: Oaks, slash pine, sweet gum, myrtle, blackberry, smilax, broomsedge.

Depth of Samples:	0 - 6 in.	6 - 14 in.	+ 14 in.
Texture:	loamy sand	loamy sand	sandy loam
Percent sand:	85.5	85.9	78.0
silt:	8.5	8.4	11.0
clay:	6.0	5.7	11.0
pH.	5.4	5.0	4.9
Nematodes Found:			
Aphelenchus avenae	+	-	-
Criconemoides ornatum	+	+	-
Ditylenchus sp.	+	-	-
Helicotylenchus nannus	+	-	-
Hoplolaimus coronatus	-	+	+
Longidorus elongatus	-	-	+
Pratylenchus brachyurus	-	+	+
Rotylenchulus reniformis	+	-	-
Trichodorus proximus	+	+	+
Tylenchus sp.	-	+	+
Tylenchus costatus	-	-	+
Xiphinema americanum	+	+	+
Xiphinemella sp.	+	-	-

TABLE A (Continued)

C-2. Norfolk Series. Site No. 1 Cultivated. August 22, 1958.

Location: Gadsden Co., Fla. SW 1/4 of SE 1/4 Sect. 8, R2W, T2N.

Vegetation: Field corn.

Depth of Sample: 0 - 8 in.

Texture: loamy sand

Percent sand:	85.0
silt:	9.0
clay:	6.0

pH. 5.8

Nematodes Found:

Criconemoides rusticum
Ditylenchus sp.
Pratylenchus zeae
Rotylenchulus reniformis
Xiphinema americanum

C-3. Norfolk Series. Site No. 2 Uncultivated. August 22, 1958.

Location: Gadsden Co., Fla. Tobacco farm, North Florida Experiment Station.

Vegetation: Oaks, longleaf pine, smut grass.

Depth of Sample: 0 - 8 in.

Texture: loamy sand

Percent sand:	80.7
silt:	10.6
clay:	8.7

pH. 4.8

Nematodes Found:

Hoplolaimus coronatus
Longidorus elongatus
Meloidogyne sp.
Pratylenchus penetrans
Rotylenchulus reniformis
Xiphinema americanum

TABLE A (Continued)

C-4. Norfolk Series. Site No. 3 Cultivated. October 10, 1957.

Location: Gadsden Co., Fla. North Florida Experiment Station.

Vegetation: Corn, peanuts, crabgrass.

Depth of Samples:	0 - 8 in.	Number of Samples: 28
Texture:	loamy sand	
Percent sand:	87.3	
silt:	9.5	
clay:	3.2	
pH.	5.1	

Nematodes Found:	Number of Samples Found In:
Belonolaimus sp.	2
Criconemoides (C. mutabile, ornatum, rusticum)	26
Hoplolaimus coronatus	2
Pratylenchus (P. brachyurus, penetrans, zeae)	28
Trichodorus (T. christiei, proximus)	25
Xiphinema americanum	9

D-1. Red Bay Series. Site No. 1 Uncultivated. August 22, 1958.

Location: Gadsden Co., Fla. NE 1/4 of SE 1/4 Sect. 17, R2W, T3N.

Vegetation: Broomsedge, sweet gum, oaks.

Depth of Samples:	0 - 6 in.	6 - 12 in.	12 - 24 in.
Texture:	loamy sand	loamy sand	sandy loam
Percent sand:	89.3	88.1	78.6
silt:	8.5	5.5	8.0
clay:	4.2	6.4	15.6
pH.	5.6	5.5	5.3
Nematodes Found:			
Xiphinema americanum	+	+	+

TABLE A (Continued)

D-2. Red Bay Series. Site No. 1 Cultivated. July 18, 1958.

Location: Gadsden Co., Fla. NE 1/4 of SE 1/4 Sect. 17, R2W, T3N.

Vegetation: Old pasture, bahia grass, broomsedge, blackberry.

Depth of Samples:	0 - 6 in.	6 - 12 in.
Texture:	loamy sand	loamy sand
Nematodes Found:		
Ditylenchus sp.	-	+
Hoplolaimus coronatus	-	+
Longidorus elongatus	-	+
Pratylenchus brachyurus	+	-
Trichodorus proximus	-	+
Tylenchus costatus	-	+
Xiphinema americanum	+	+

D-3. Red Bay Series. Site No. 2 Cultivated. August 13, 1956.

Location: Jackson Co., Fla. Marianna Mobile Unit. Rotation plots.

Vegetation: Corn, peanuts, soybeans.

Depth of Sample:	0 - 8 in.
Texture:	sandy loam
Percent sand:	77.0
silt:	10.2
clay:	12.8

Nematodes Found:

Criconemoides sp.
Meloidogyne javanica
Pratylenchus brachyurus
Trichodorus christiei
Trichodorus proximus
Xiphinema americanum

TABLE A (Continued)

D-4. Red Bay Series. Site No. 2 Cultivated. October 11, 1957.

Location: Jackson Co., Fla. Marianna Mobile Unit, Rotation plots.

Vegetation: Corn, peanuts.

Depth of Samples: 0 - 8 in. Number of Samples: 36

Texture: sandy loam

Nematodes Found:	Number Samples Found In:
Criconemoides (C. mutabile, ornatum)	35
Hoplolaimus coronatus	1
Pratylenchus (P. brachyurus, zeae)	35
Trichodorus (T. christiei, proximus)	25
Xiphinema americanum	17

D-5. Red Bay Series. Site No. 3 Cultivated. May 11, 1958.

Location: Jefferson Co., Fla. SW 1/4 of NW 1/4 Sect. 24, R4E, T3N.

Vegetation: Tung oil trees, bahia grass.

Depth of Sample: 0 - 8 in.

Texture: sandy loam

Percent sand:	72.5
silt:	13.8
clay:	13.7

Nematodes Found:

Ditylenchus sp.
Pratylenchus zeae
Trichodorus christiei
Tylenchus costatus
Xiphinema americanum

TABLE A (Continued)

D-6. Red Bay Series. Site No. 3 Uncultivated. May 11, 1958.

Location: Jefferson Co., Fla. SW 1/4 of NW 1/4 Sect. 24, R4E, T3N.

Vegetation: Sweet gum, elder, broomsedge, blackberry.

Depth of Sample:	0 - 8 in.
Texture:	sandy loam
Percent sand:	77.0
silt:	10.7
clay:	12.3

Nematodes Found:

Ditylenchus sp.
Trichodorus christiei
Tylenchus sp.
Xiphinema americanum

D-7. Red Bay Series. Site No. 4 Cultivated. May 11, 1958.

Location: Jefferson Co., Fla. NW 1/4 of NE 1/4 Sect. 25, R4E, T3N.

Vegetation: Native cover.

Depth of Sample:	0 - 8 in.
Texture:	loamy sand
Percent sand:	84.5
silt:	6.0
clay:	9.5

Nematodes Found:

Trichodorus proximus
Xiphinema americanum

TABLE A (Continued)

D-8. Red Bay Series. Site No. 5 Cultivated. July 31, 1957.

Location: Santa Rosa Co., Fla. West Florida Experiment Station Rotation Plots.

Vegetation: Corn, peanuts, soybeans.

Depth of Samples: 0 - 8 in. Number of Samples: 28

Texture: fine sandy loam

Nematodes Found:	Number Samples Found In:
Criconemoides sp.	21
Pratylenchus (P. penetrans, scribneri, zeae)	28
Trichodorus (T. christiei)	26

E-1. Ruston Series. Site No. 1 Uncultivated. July 17, 1958.

Location: Gadsden Co., Fla. North boundary, NW 1/4 Sect. 2, R4W, T2N.

Vegetation: Oak, persimmon, blackberry, broomsedge.

Depth of Sample:	0 - 6 in.	6 - 18 in.
Texture:	loamy sand	loamy sand
Percent sand:	84.0	82.6
silt:	10.6	11.4
clay:	5.4	6.0
pH.	5.7	5.5

Nematodes Found:		
Criconemoides rusticum	+	-
Ditylenchus sp.	+	+
Hemicriconemoides wessoni	+	-
Longidorella sp.	-	+
Pungentus sp.	-	+
Tylenchus costatus	+	-
Tylenchus minutus	+	-

TABLE A (Continued)

E-2. Ruston Series. Site No. 1 Cultivated. May 17, 1958.

Location: Gadsden Co., Fla. Opposite E-1, across State Road 488.

Vegetation: Corn.

Depth of Sample:	0 - 6 in.	6 - 18 in.
Texture:	loamy sand	loamy sand
Nematodes Found:		
Criconemoides ornatum	+	+
Criconemoides rusticum	+	-
Pratylenchus brachyurus	+	+
Pratylenchus penetrans	-	+
Pratylenchus zeae	+	+
Trichodorus christiei	+	-

E-3. Ruston Series. Site No. 2 Cultivated. August 22, 1958.

Location: Gadsden Co., Fla. Near Tobacco Farm. North Florida Experiment Station.

Vegetation: Corn.

Depth of Sample:	0 - 8 in.
Texture:	fine sandy loam
Nematodes Found:	
Criconemoides rusticum	
Pratylenchus brachyurus	
Pratylenchus zeae	

TABLE A (Continued)

E-4. Ruston Series. Site No. 2 Uncultivated. August 22, 1958.

Location: Gadsden Co., Fla. 1.6 mi. N. Old Tobacco Station, North Florida Experiment Station.

Vegetation: French mulberry, oak, smilax.

Depth of Sample:	0 - 8 in.
Texture:	loamy sand
Percent sand:	83.1
silt:	12.2
clay:	4.7
pH.	5.5

Nematodes Found:

Criconemoides rusticum

Pratylenchus brachyurus

Trichodorus proximus

Xiphinema americanum

TABLE A (Continued)

F-1. Tifton Series. Site No. 1 Uncultivated. August 22, 1958.

Location: Gadsden Co., Fla. NW 1/4 of NE 1/4 Sect. 21, R4W, T3N.

Vegetation: Turkey oak, long leaf pine, wiregrass, huckleberry, *Vicia* sp., blackberry.

Depth of Sample:	0 - 4 in.	4 - 10 in.	+ 10 in.
Texture:	loamy sand	loamy sand	sandy loam
Percent sand:	79.3	79.6	70.6
silt:	15.5	15.0	12.0
clay:	5.2	5.4	17.4
pH.	5.6	5.7	5.4

Nematodes Found:

Criconemoides cylindricum	+	-	-
Helicotylenchus nannus	+	-	-
Hemicycliophora similis	-	+	+
Hoplolaimus gadsdensis	+	+	-
Longidorus elongatus	-	+	+
Paratylenchus sp.	+	-	+
Pratylenchus brachyurus	-	+	-
Tylenchorhynchus claytoni	+	-	-
Xiphinema americanum	+	-	-

TABLE A (Continued)

F-2. Tifton Series. Site No. 2 Cultivated. July 19, 1958.

Location: Gadsden Co., Fla. Northwest Pasture, North Florida Experiment Station.

Vegetation: Coastal Bermudagrass.

Depth of Sample: 0 - 8 in. Number of Samples: 8

Texture: loamy sand

Nematodes Found:	Number Samples Found in:
Criconemoides (C. ornatum)	7
Helicotylenchus (H. nannus)	6
Pratylenchus (P. zeae)	5
Trichodorus (T. christiei, proximus)	8
Xiphinema americanum	3

G-1. Faceville Series. Site No. 1 Cultivated. May 16, 1958.

Location: Gadsden Co., Fla. Tobacco Farm, Entomology Shade, North Florida Experiment Station.

Vegetation: Cocklebur, Amaranthus sp., tobacco.

Depth of Samples: 0 - 8 in.

Texture: sandy loam

Percent sand:	72.9
silt:	16.1
clay:	11.0

pH. 5.5

Nematodes Found:

Criconemoides ornatum
Helicotylenchus nannus
Hemicycliophora sp.
Pratylenchus brachyurus
Pratylenchus penetrans
Trichodorus sp.

TABLE A (Continued)

H-1. Marlboro Series. Site No. 1 Cultivated. May 18, 1957.

Location: Gadsden Co., Fla. "Variety Shade" Tobacco Farm, North Florida Experiment Station.

Vegetation: Shade tobacco.

Depth of Samples: 0 - 10 in. Number of Samples: 40

Texture: fine sandy loam

Nematodes Found:	Number Samples Found In:
Criconemoides (C. ornatum)	8
Helicotylenchus (H. nannus)	37
Meloidogyne (M. incognita acrita)	2
Pratylenchus (P. brachyurus, penetrans)	10
Trichodorus (T. proximus)	4
Xiphinema americanum	1

H-2. Marlboro Series. Site No. 2 Cultivated. February 4, 1958.

Location: Gadsden Co., Fla. "Entomology Shade," Tobacco Farm, North Florida Experiment Station.

Vegetation: Cocklebur, Amaranthus sp.

Depth of Sample: 0 - 6 in.

Texture: sandy loam

Percent sand:	78.1
silt:	12.6
clay:	9.3

Nematodes Found:

Criconemoides spp.
Pratylenchus brachyurus
Pratylenchus penetrans
Trichodorus christiei
Trichodorus proximus
Xiphinema americanum

TABLE B

NEMATODES FOUND IN IMPERFECTLY TO POORLY DRAINED SANDS AND LOAMY SANDS[a]

A-1. Arzell Series. Site No. 1 Cultivated. March 19, 1956.

Location: Broward Co., Fla. Deerfield Beach.

Vegetation: Lawn.

Depth of Sample: 0 - 6 in.

Texture: fine sand

Nematodes Found:

Dolichodorus heterocephalus

Hoplolaimus coronatus

Xiphinema sp.

A-2. Arzell Series. Site No. 2 Cultivated. September 10, 1956.

Location: Dade Co., Fla.

Vegetation: Lawn.

Depth of Sample: 0 - 4 in.

Texture: fine sand

Nematodes Found:

Helicotylenchus sp.

Hoplolaimus coronatus

Xiphinema sp.

[a]One sample per site or depth unless otherwise indicated.

TABLE B (Continued)

A-3. Arzell Series. Site No. 3 Cultivated. November 15, 1958.

Location: Palm Beach Co., Fla. Lake Worth.

Vegetation: Unimproved pasture, smut grass, Natal.grass. Planted to tomatoes about 1943.

Depth of Sample: 0 - 8 in.

Texture: fine sand

Nematodes Found:

Belonolaimus longicaudatus

Hemicriconemoides wessoni

A-4. Arzell Series. Site No. 3 Cultivated. November 18, 1958.

Location: Palm Beach Co., Fla. Lake Worth. Thirty yards from sample A-3.

Vegetation: Tomatoes.

Depth of Sample: 0 - 6 in.

Texture: fine sand

Nematodes Found:

Criconemoides ornatum

Meloidogyne sp.

Trichodorus christiei

Xiphinema radicicola

TABLE B (Continued)

A-5. Arzell Series. Site No. 4 Cultivated. February 11, 1955.

Location: Palm Beach Co., Fla.

Vegetation: Zoysia sod.

Depth of Sample: 0 - 4 in.

Texture: sand

Nematodes Found:

Belonolaimus sp.

Hoplolaimus coronatus

Trichodorus christiei

A-6. Arzell Series. Site No. 5 Cultivated. May 7, 1955.

Location: Palm Beach Co., Fla.

Vegetation: Pineapple.

Depth of Sample: 0 - 8 in.

Texture: sand

Nematodes Found:

Hemicycliophora parvana

Hoplolaimus coronatus

TABLE B (Continued)

B-1. Bladen Series. Site No. 1 Uncultivated. September 19, 1957.

Location: Alachua Co., Fla. NW 1/4 of SE 1/4 Sect. 20, R22E, T9S.

Vegetation: Slash pine, sedges.

Depth of Sample: 0 - 8 in.

Texture: loamy sand

Nematodes Found:

Trichodorus proximus
Tylenchorhynchus sp.

B-2. Bladen Series. Site No. 2 Cultivated. November 10, 1955.

Location: St. Johns Co., Fla. Hastings.

Vegetation: Cauliflower.

Texture: loamy sand

Nematodes Found:

Belonolaimus sp.
Helicotylenchus sp.

B-3. Bladen Series. Site No. 3 Cultivated. October 14, 1955.

Location: St. Lucie Co., Fla. Indian River Field Laboratory.

Vegetation: Bermudagrass (old tomato field).

Depth of Sample: 0 - 8 in.

Texture: fine sandy loam

Nematodes Found:

Dolichodorus heterocephalus
Helicotylenchus sp.
Hemicycliophora sp.
Trichodorus christiei

TABLE B (Continued)

C-1. Immokalee Series. Site No. 1 Cultivated. August 20, 1955.

Location: St. Lucie Co., Fla. Indian River Field Laboratory.

Vegetation: Pangola grass.

Depth of Sample: 0 - 6 in.

Texture: fine sand

Nematodes Found:

Belonolaimus sp.
Criconemoides sp.
Dolichodorus heterocephalus
Hemicycliophora parvana
Meloidogyne sp.
Trichodorus sp.
Xiphinema americanum

C-2. Immokalee Series. Site No. 2 Cultivated. March 16, 1956.

Location: St. Lucie Co., Fla. Indian River Field Laboratory.

Vegetation: Old pasture, Bermudagrass.

Depth of Sample: 0 - 6 in.

Texture: fine sand

Nematodes Found:

Dolichodorus heterocephalus
Helicotylenchus pannus
Hemicycliophora parvana
Hoplolaimus coronatus
Pratylenchus brachyurus
Scutellonema cohni
Trichodorus christiei
Tylenchorhynchus claytoni

TABLE B (Continued)

C-3. Immokalee Series. Site No. 3 Cultivated. March 30, 1957.

Location: St. Lucie Co., Fla. Indian River Field Laboratory.

Vegetation: Pasture.

Texture: fine sand

Nematodes Found:

Dolichodorus heterocephalus
Radopholus oryzae
Scutellonema christiei

D-1. Leon Series. Site No. 1 June 11, 1957.

Location: Alachua Co., Fla. NW 1/4 of NE 1/4 Sect. 35, Williamson Tract. University of Florida.

Vegetation: Cultivated - corn, millet.
Uncultivated - sedges, wiregrass.

Depth of Sample: 0 - 8 in.

Texture: fine sand

Nematodes Found:	Cultivated	Uncultivated
Criconemoides rusticum	+	-
Helicotylenchus nannus	+	+
Hoplolaimus coronatus	+	-
Pratylenchus brachyurus	+	-
Trichodorus christiei	+	+

TABLE B (Continued)

D-2. Leon Series. Site No. 2 Cultivated. October 13, 1955.

Location: Duval Co., Fla.

Vegetation: Bermudagrass.

Texture: fine sand Number of Samples: 20

Nematodes Found:	Number Samples Found In:
Belonolaimus sp.	8
Criconemoides sp.	13
Helicotylenchus sp.	18
Hemicycliophora sp.	4
Hoplolaimus coronatus	20
Tylenchorhynchus sp.	13

D-3. Leon Series. Site No. 3 Cultivated. August 16, 1956.

Location: Levy Co., Fla.

Vegetation: Peanuts.

Texture: fine sand

Nematodes Found:

Pratylenchus brachyurus

D-4. Leon Series. Site No. 4 Uncultivated. January 16, 1958.

Location: Orange Co., Fla. Union Park Vegetable Plots, Orlando.

Vegetation: Slash pine, palmetto, wiregrass, sedges.

Texture: fine sand Number of Samples: 3

Nematodes Found:	Number of Samples Found In:
Dolichodorus heterocephalus	1
Helicotylenchus nannus	3
Hemicycliophora sp.	2
Hoplolaimus coronatus	1
Pratylenchus brachyurus	2
Tylenchus sp.	1

TABLE B (Continued)

D-5. Leon Series. Site No. 5 Cultivated. May 2, 1955.

Location: Pinellas Co., Fla.

Vegetation: Zoysia sod.

Texture: fine sand

Nematodes Found:

Belonolaimus sp.

Ditylenchus intermedius

Hoplolaimus coronatus

D-6. Leon Series. Site No. 6 Cultivated. March 3, 1955.

Location: St. Lucie Co., Fla.

Vegetation: Sod.

Texture: fine sand

Nematodes Found:

Belonolaimus sp.

Helicotylenchus sp.

Hoplolaimus coronatus

Trichodorus sp.

TABLE B (Continued)

E-1. Ona Series. Site No. 1 June 11, 1957.

Location: Alachua Co., Fla. Hague, near Dairy Farm.

Vegetation: Cultivated - Native cover.
Uncultivated - Sweet gum, blackberry, palmetto.

Depth of Sample: 0 - 12 in.

Texture: fine sand

Nematodes Found:	Cultivated	Uncultivated
Belonolaimus sp.	+	-
Criconemoides sp.	+	-
Helicotylenchus nannus	+	+
Hemicycliophora sp.	-	+
Trichodorus sp.	+	-

E-2. Ona Series. Site No. 2 Cultivated. July 11, 1957.

Location: Alachua Co., Fla. Sect. 15, R19E, T9S. Field 10-D.

Vegetation: Bahia grass, hairy indigo, millet.

Depth of Samples: 0 - 12 in. Number of Samples: 8

Texture: fine sand

Nematodes Found:	Number Samples Found In:
Belonolaimus (B. longicaudatus)	2
Dolichodorus heterocephalus	1
Helicotylenchus (H. nannus)	1
Hoplolaimus coronatus	5
Pratylenchus (P. brachyurus, zeae)	2
Trichodorus (T. christiei)	5
Xiphinema americanum	2

TABLE B (Continued)

E-3. One Series. Site No. 3 Uncultivated. July 11, 1957.

Location: Alachua Co., Fla. Sect. 15, R19E, T9S. In woods near Field 10-D.

Vegetation: Pine, palmetto, wiregrass, dwarf oaks.

Depth of Samples: 0 - 12 in. Number of Samples: 8

Texture: fine sand

Nematodes Found:	Number Samples Found In:
Belonolaimus (B. longicaudatus)	2
Criconemoides sp.	1
Helicotylenchus (H. erythrinae, nannus)	5
Hoplolaimus coronatus	6
Meloidodera floridensis	4
Pratylenchus (P. brachyurus, zeae)	2
Trichodorus (T. christiei)	4
Xiphinema (X. americanum)	2

F-1. Plummer Series. Site No. 1 Uncultivated. January 17, 1958.

Location: Alachua Co., Fla. Austin Cary Forest.

Vegetation: Slash pine, broomsedge, wiregrass.

Depth of Sample: 0 - 6 in. 1 - 2 ft. 2 - 3 ft.

Texture: fine sand

Nematodes Found:			
Criconemoides sp.	–	–	+
Dolichodorus sp.	+	–	–
Ecphyadophora sp.	+	+	–
Hemicycliophora sp.	+	–	–
Hoplolaimus coronatus	+	–	+
Meloidodera floridensis	+	–	+
Meloidogyne sp.	+	–	–

TABLE B (Continued)

F-2. Plummer Series. Site No. 2 Cultivated. July 29, 1955.

Location: Lee Co., Fla.

Vegetation: Zoysia sod.

Nematodes Found:

Belonolaimus sp.
Hoplolaimus coronatus

G-1. Rex Series. Site No. 1 Cultivated. April 28, 1955.

Location: Alachua Co., Fla. Orange Heights.

Vegetation: Not recorded.

Texture: loamy sand

Nematodes Found:

Belonolaimus sp.
Criconemoides sp.
Helicotylenchus erythrinae
Pratylenchus brachyurus
Trichodorus christiei

G-2. Rex Series. Site No. 2 Cultivated. April 29, 1955.

Location: Alachua Co., Fla.

Vegetation: Pecan trees.

Depth of Sample: 0 - 12 in.

Texture: fine sand

Nematodes Found:

Hemicycliophora sp.
Hoplolaimus coronatus
Trichodorus sp.
Xiphinema americanum

TABLE B (Continued)

G-3. Rex Series. Site No. 3 Cultivated. May 19, 1955.

Location: Alachua Co., Fla. 1/4 mi. E. of Orange Heights on S.R.No.21.

Vegetation: Cucumbers.

Texture: loamy fine sand

Nematodes Found:

Dolichodorus heterocephalus
Helicotylenchus sp.
Hoplolaimus coronatus
Xiphinema sp.

G-4. Rex Series. Site No. 4 Uncultivated. July 19, 1957.

Location: Alachua Co., Fla. Sect. 20, R22E, T9S, 800 ft. East of U.S. No. 301.

Vegetation: Slash pine, native grasses, broomsedge.

Depth of Sample: 0 - 22 in.

Texture: loamy sand over sandy clay Number of Samples: 4

Nematodes Found:	Number Samples Found In:
Criconemoides rusticum	1
Ditylenchus sp.	1
Ecphyadophora sp.	1
Helicotylenchus nannus	1
Hoplolaimus coronatus	2
Meloidogyne incognita acrita	1
Pratylenchus brachyurus	1
Trichodorus proximus	4
Trophurus sculptus	2
Tylenchorhynchus sp.	2

TABLE B (Continued)

H-1. Scranton Series. Site No. 1 Cultivated. November 6, 1956.

Location: Alachua Co., Fla.

Vegetation: Squash.

Texture. fine sand

Nematodes Found:

Criconemoides sp.

Meloidogyne sp.

Trichodorus sp.

Xiphinema sp.

H-2. Scranton Series. Site No. 2 Cultivated. January 28, 1957.

Location: Bradford Co., Fla.

Vegetation: Strawberries.

Texture: fine sand

Nematodes Found:

Aphelenchoides besseyi

Belonolaimus sp.

Criconemoides sp.

Hoplolaimus coronatus

Xiphinema sp.

TABLE B (Continued)

H-3. Scranton Series. Site No. 3 Cultivated. July 29, 1958.

Location: Suwannee Co., Fla. NW 1/4 of SE 1/4 Sect. 2, R14E, T2S.

Vegetation: Corn.

Depth of Sample:	0 - 6 in.	
Texture:	fine sand	Number of Samples: 2
Percent sand:	91.3	
silt:	4.5	
clay:	4.2	
pH.	4.8	

Nematodes Found:	Number Samples Found In:
Belonolaimus longicaudatus	1
Criconemoides (C. mutabile, ornatum)	2
Hoplolaimus coronatus	1
Pratylenchus (P. brachyurus, zeae)	2
Trichodorus christiei	1
Xiphinema americanum	1

TABLE C

NEMATODES FOUND IN POORLY TO VERY POORLY DRAINED PEATS AND MUCKS[a]

A-1. Everglades Series. Site No. 1 Cultivated. February 7, 1955.

Location: Broward Co., Fla. 4 mi. Northwest of Davie.

Vegetation: St. Augustine grass.

Nematodes Found:

Helicotylenchus nannus

A-2. Everglades Series. Site No. 2 Cultivated. August 15, 1956.

Location: Dade Co., Fla.

Vegetation: St. Augustine grass.

Nematodes Found:

Xiphinema americanum

Xiphinema divirsicaudatum

A-3. Everglades Series. Site No. 3 Cultivated. February 16, 1955.

Location: Hendry Co., Fla. near Bear Beach.

Vegetation: Ramie.

Nematodes Found:

Pratylenchus brachyurus

[a]One sample per site unless otherwise indicated.

TABLE C (Continued)

A-4. Everglades Series. Site No. 4 Cultivated. November 18, 1958.

Location: Palm Beach Co., Fla. Field 5E-8, Everglades Experiment Station.

Vegetation: Sugar cane.

Nematodes Found:

Pratylenchus zeae
Scutellonema brachyurus
Tylenchorhynchus martini

A-5. Everglades Series. Site No. 5 Cultivated. November 18, 1958.

Location: Palm Beach Co., Fla. Field 2-SE, Everglades Experiment Station.

Vegetation: Celery.

Nematodes Found:

Helicotylenchus erythrinae
Pratylenchus zeae
Trichodorus sp.
Tylenchorhynchus martini

A-6. Everglades Series. Site No. 6 Uncultivated. November 18, 1958.

Location: Palm Beach Co., Fla. Field No. 6E-8, Everglades Experiment Station.

Vegetation: Elderberry, saw grass, Amaronthus sp.

Nematodes Found:

Helicotylenchus erythrinae
Trichodorus christiei

TABLE C (Continued)

A-7. Everglades Series. Site No. 7 Cultivated. November 24, 1956.

Location: Palm Beach Co., Fla. Field No. 7W, Everglades Experiment Station.

Vegetation: St. Augustine grass.

Nematodes Found:

Criconemoides rusticum

Helicotylenchus nannus

Pratylenchus brachyurus

Pratylenchus scribneri

TABLE D

NEMATODES FOUND IN WELL TO EXCESSIVELY DRAINED SANDS AND LOAMY SANDS[a]

A-1. Arredondo Series. Site No. 1 Cultivated. September 29, 1955.

Location: Alachua Co., Fla. Agronomy Farm, Florida Agricultural Experiment Station.

Vegetation: Soybeans.

Depth of Sample: 0 - 8 in.

Texture: fine sand Number of Samples: 5

Nematodes Found:	Number Samples Found In:
Belonolaimus sp.	4
Meloidogyne (M. incognita acrita, javanica)	1
Pratylenchus sp.	4

A-2. Arredondo Series. Site No. 2 Cultivated. February 16, 1955.

Location: Alachua Co., Fla. near Horticulture Greenhouses, Archer Rd., University of Florida.

Vegetation: Roses, Rosa chinensis.

Depth of Sample: root zone.

Texture: fine sand

Nematodes Found:

Meloidogyne hapla

[a]One sample per site or depth unless otherwise indicated.

TABLE D (Continued)

A-3. Arredondo Series. Site No. 3 Cultivated. November 14, 1958.

Location: Alachua Co., Fla. Agronomy Farm, Florida Agricultural Experiment Station.

Vegetation: Soybeans.

Depth of Sample: 0 - 8 in.

Texture: fine sand Number of Samples: 8

Nematodes Found:	Number Samples Found In:
Belonolaimus (B. longicaudatus)	5
Hoplolaimus coronatus	2
Meloidogyne sp.	6
Pratylenchus (P. brachyurus, penetrans)	8
Trichodorus (T. christiei, proximus)	8

A-4. Arredondo Series. Site No. 4 Cultivated. September 20, 1957.

Location: Alachua Co., Fla. East field, Agronomy Farm, Florida Agricultural Experiment Station.

Vegetation: Hairy indigo, volunteer peanuts, Bahia grass.

Depth of Sample: 0 - 8 in.

Texture: loamy sand Number of Samples: 7

Nematodes Found:	Number Samples Found In:
Aphelenchus avenae	3
Criconemoides (C. ornatum)	4
Pratylenchus (P. brachyurus)	3
Xiphinema americanum	2
Trichodorus christiei	1

TABLE D (Continued)

A-5. Arredondo Series. Site No. 5 Uncultivated. September 16, 1957.

Location: Alachua Co., Fla. Horticulture Unit, Florida Agricultural Experiment Station.

Vegetation: Native cover disced under.

Depth of Sample: 0 - 8 in.

Texture: fine sand

Nematodes Found:

Belonolaimus longicaudatus
Criconemoides rusticum
Ditylenchus sp.
Longidorus sp.
Tylenchus sp.

A-6. Arredondo Series. Site No. 6 Uncultivated. September 16, 1957.

Location: Alachua Co., Fla. near North boundary, Horticulture Unit, Florida Agricultural Experiment Station.

Vegetation: Palmetto, hickory.

Depth of Samples: 0 - 8 in.

Texture: fine sand Number of Samples: 4

Nematodes Found:	Number Samples Found In:
Criconemoides rusticum	1
Ecyphyadophora sp.	1
Hoplolaimus coronatus	1
Longidorus sp.	2
Pratylenchus brachyurus	1
Trichodorus (T. christiei)	3
Xiphinema americanum	2

TABLE D (Continued)

A-7. Arredondo Series. Site No. 7 Uncultivated. May, 1957.

Location: Alachua Co., Fla. 100 ft. west of Southwest corner Parking Area 7, University of Florida.

Vegetation: Tradescantia sp. sweet gum, magnolia, grapevines.

Depth of Sample: 0 - 8 in.

Texture: fine sand Number of Samples: 18

Nematodes Found:	Number Samples Found In:
Belonolaimus sp.	6
Criconemoides sp.	4
Ditylenchus sp.	2
Ecphyadophora sp.	1
Helicotylenchus sp.	9
Hoplolaimus coronatus	1
Meloidogyne sp.	2
Pratylenchus sp.	1
Trophotylenchus floridensis	18
Tylenchus sp.	2
Xiphinema sp.	18

A-8. Arredondo Series. Site No. 8 Cultivated. July 28, 1958.

Location: Suwannee Co., Fla. SW 1/4 of NE 1/4 Sect. 15, R14E, T2S.

Vegetation: Corn.

Depth of Sample: 0 - 6 in.

Texture: fine sand

Nematodes Found:

Pratylenchus brachyurus
Pratylenchus zeae
Trichodorus christiei
Xiphinema americanum

TABLE D (Continued)

A-9. Arredondo Series. Site No. 9 Cultivated. March 26, 1956.

Location: Alachua Co., Fla. SE corner Field 19A, Agronomy Farm, Florida Agricultural Experiment Station.

Vegetation: None, Prepared for planting.

Depth of Samples: 0 - 8 in.

Texture: fine sand Number of Samples: 16

Nematodes Found:	Number Samples Found In:
Belonolaimus sp.	9
Criconemoides (C. ornatum)	5
Hoplolaimus coronatus	2
Pratylenchus (P. brachyurus)	6
Trichodorus (T. christiei, proximus)	10

B-1. Blanton Series. Site No. 1 Cultivated. July 5, 1955.

Location: Alachua Co., Fla. near Melrose.

Vegetation: St. Augustine grass.

Depth of Sample: 0 - 6 in.

Texture: fine sand

Nematodes Found:

Belonolaimus sp.
Criconemoides sp.
Hoplolaimus coronatus
Trichodorus sp.
Xiphinema sp.

TABLE D (Continued)

B-2. Blanton Series. Site No. 2 Cultivated. February 25, 1958.

Location: Alachua Co., Fla. Sect. 13, R22E, T9S.

Vegetation: Pecan.

Depth of Sample: 0 - 8 in.

Nematodes Found:

Xiphinema americanum

B-3. Blanton Series. Site No. 3 Cultivated. July 28, 1958.

Location: Suwannee Co., Fla. SE 1/4 of SE 1/4 Sect. 11, R14E, T5S.

Vegetation: Watermelon, volunteer peanuts, Phytolacca sp.

Depth of Sample:	0 - 6 in.	6 - 12 in.
Texture:	fine sand	fine sand
Percent sand:	94.9	94.9
silt:	3.4	3.4
clay:	1.7	1.7
pH.	5.5	5.5

Nematodes Found:

Ditylenchus sp.	-	+
Pratylenchus brachyurus	+	-
Scutellonema sp.	+	+
Scutellonema christiei	+	-
Trichodorus proximus	+	+
Tylenchus sp.	-	+
Xiphinema sp.	+	+

TABLE D (Continued)

B-4. Blanton Series. Site No. 4 Uncultivated. July 28, 1958.

Location: Suwannee Co., Fla. NW 1/4 of NE 1/4, Sect. 14, R14E, T5S.

Vegetation: Turkey oak, hickory, smut grass.

Depth of Sample:	0 - 4 in.	4 -8 in.
Texture:	fine sand	fine sand
Percent sand:	95.3	96.5
silt:	3.4	2.4
clay:	1.3	1.2
pH.	4.9	5.2

Nematodes Found:

Longidorus sp.	-	+
Scutellonema sp.	+	+
Scutellonema brachyurus	-	+
Trichodorus proximus	+	+
Trophotylenchulus floridensis	+	+
Xiphinema americanum	+	+

B-5. Blanton Series. Site No. 4 Uncultivated. July 28, 1958.

Location: Same as B-4 above.

Vegetation: Same as B-4 above.

Texture: Same as B-4 above.

Depth of Sample: 0 - 8 in.

Nematodes Found:

Helicotylenchus nannus
Hemicriconemoides wessoni
Longidorus sp.
Scutellonema christiei
Trophotylenchulus floridensis
Xiphinema sp.

TABLE D (Continued)

C-1. Eustis Series. Site No. 1 Cultivated. February 21, 1955.

Location: Lake Co., Fla. Tavares.

Vegetation: Citrus, pecan.

Texture: fine sand

Nematodes Found:

Belonolaimus sp.

Xiphinema americanum

C-2. Eustis Series. Site No. 2 Cultivated. May 8, 1955.

Location: Seminole Co., Fla.

Vegetation: Centipede grass.

Texture: fine sand

Nematodes Found:

Belonolaimus sp.

TABLE D (Continued)

D-1. Fellowship Series. Site No. 1 Cultivated. August 10, 1955.

Location: Alachua Co., Fla. Turf Research Plots, Florida Agricultural Experiment Station.

Vegetation: Bermudagrass.

Depth of Sample: 0 - 6 in.

Texture: fine sand Number of Samples: 15

Nematodes Found:	Number Samples Found In:
Belonolaimus sp.	14
Criconemoides sp.	15
Helicotylenchus sp.	10
Hoplolaimus coronatus	12
Xiphinema americanum	7

D-2. Fellowship Series. Site No. 2 Uncultivated. July 28, 1958.

Location: Suwannee Co., Fla. NW 1/4 of NW 1/4, Sect. 7, R14E, T2S.

Vegetation: Longleaf pine, broomsedge.

Depth of Sample: 0 - 6 in.

Texture: loamy sand

Percent sand:	83.5
silt:	9.3
clay:	7.2

pH. 5.2

Nematodes Found:

Criconemoides mutabile
Helicotylenchus erythrinae
Hoplolaimus coronatus
Trichodorus proximus

TABLE D (Continued)

K-1. Fort Meade Series. Site No. 1 Uncultivated. September 16, 1957.

Location: Alachua Co., Fla. near North Boundary, Horticulture Unit, Florida Agricultural Experiment Station.

Vegetation: Blackberry, hickory, sedges.

Depth of Sample: 0 - 8 in.

Texture: loamy fine sand Number of Samples: 3

Nematodes Found:	Number Samples Found In:
Ditylenchus sp.	2
Pratylenchus sp.	1
Trichodorus (T. christiei)	2
Trophotylenchulus floridensis	2
Tylenchus sp.	2

K-2. Fort Meade Series. Site No. 2 Uncultivated. July 28, 1958.

Location: Suwannee Co., Fla. NW 1/4 of NE 1/4, Sect. 8, R14E, T4S.

Vegetation: Longleaf pine, sweet gum, wiregrass.

Depth of Sample:	0 - 6 in.	8 - 12 in.
Texture:	loamy sand	loamy sand
Percent sand:	86.1	84.7
silt:	8.1	11.1
clay:	5.8	4.2
pH.	5.5	5.5

Nematodes Found:		
Helicotylenchus erythrinae	+	-
Hoplolaimus coronatus	+	-
Xiphinema sp.	-	+
Xiphinema longicaudatus	+	-

TABLE D (Continued)

F-1. Gainesville Series. Site No. 1 Cultivated. September 17, 1957.

Location: Alachua Co., Fla. NW 1/4 of NE 1/4, Sect. 14, R18E, T9S.

Vegetation: Bermudagrass, Richardia scabra St. Hil.

Depth of Sample: 0 - 6 in.

Texture: loamy fine sand Number of Samples: 4

Nematodes Found:	Number Samples Found In:
Aphelenchus sp.	1
Criconemoides (C. rusticum)	2
Ditylenchus sp.	2
Helicotylenchus (H. nannus)	2
Hoplolaimus coronatus	1
Meloidogyne sp.	1
Pratylenchus (P. brachyurus)	4
Trichodorus (T. christiei)	2
Tylenchorhynchus sp.	1
Xiphinema (X. longicaudatus)	4

F-2. Gainesville Series. Site No. 2 Uncultivated. September 17, 1958.

Location: Alachua Co., Fla. SE 1/4 of NE 1/4, Sect. 15, R18E, T9S.

Vegetation: Oak - hickory woodland.

Depth of Sample:	0 - 8 in.	12 - 24 in.
Texture:	loamy fine sand	--
Nematodes Found:		
Criconemoides rusticum	+	+
Longidorus sp.	+	+
Trichodorus christiei	+	-
Trophotylenchulus floridensis	+	+
Xiphinema sp.	-	+
Xiphinema americanum	+	-

TABLE D (Continued)

F-3. Gainesville Series. Site No. 3 Cultivated. July 28, 1958.

Location: Suwannee Co., Fla. NW 1/4 of NW 1/4, Sect. 3, R14E, T2S.

Vegetation: Corn.

Depth of Sample: 0 - 8 in.

Texture: fine sand

Percent sand: 89.0
silt: 5.8
clay: 5.2

pH. 5.7

Nematodes Found:

Criconemoides cylindricum

Pratylenchus brachyurus

Pratylenchus zeae

Xiphinema americanum

F-4. Gainesville Series. Site No. 4 Uncultivated. July 28, 1958.

Location: Suwannee Co., Fla. SW 1/4 of SW 1/4, Sect. 34, R14E, T1S.

Vegetation: Bare soil under oak.

Depth of Sample: 0 - 8 in.

Texture: loamy sand

Nematodes Found:

Trichodorus proximus

TABLE D (Continued)

G-1. Kanapaha Series. Site No. 1 Cultivated. March 13, 1956.

Location: Alachua Co., Fla.

Vegetation: St. Augustine grass.

Texture: fine sand

Nematodes Found:

Helicotylenchus sp.

Hoplolaimus coronatus

G-2. Kanapaha Series. Site No. 2 Cultivated. February 22, 1957.

Location: Alachua Co., Fla.

Vegetation: St. Augustine grass.

Nematodes Found:

Belonolaimus longicaudatus

Hoplolaimus coronatus

Xiphinema americanum

TABLE D (Continued)

G-3. Kanapaha Series. Site No. 3 Cultivated. July 11, 1957.

Location: Alachua Co., Fla., East margin Field 10-D, Horticulture Unit, Florida Agricultural Experiment Station.

Vegetation: Corn, soybeans.

Depth of Samples: 0 - 8 in.

Texture: fine sand Number of Samples: 7

Nematodes Found:	Number Samples Found In:
Aphelenchus avenae	2
Belonolaimus sp.	1
Dolichodorus heterocephalus	4
Ecphyadophora tenuissima	1
Helicotylenchus (H. nannus)	1
Hoplolaimus coronatus	2
Pratylenchus (P. zeae)	3
Trichodorus (T. christiei)	3

G-4. Kanapaha Series. Site No. 4 Uncultivated. July 11, 1957.

Location: Alachua Co., Fla. East margin Field 10-D and adjacent woodland, Horticultural Unit, Florida Agricultural Experiment Station.

Vegetation: Dwarf oak, palmetto, slash pine, gallberry, wiregrass.

Depth of Samples: 0 - 8 in.

Texture: fine sand Number of Samples: 7

Nematodes Found:	Number Samples Found In:
Aphelenchus avenae	1
Criconemoides (C. ornatum)	1
Ditylenchus sp.	1
Dolichodorus heterocephalus	1
Ecphyadophora sp.	1
Helicotylenchus (H. erythrinae, nannus)	3
Hoplolaimus coronatus	2
Longidorus elongatus	1
Scutellonema brachyurus	1
Trichodorus (T. christiei, proximus)	4
Xiphinema americanum	1

TABLE D (Continued)

H-1. Lakeland Series. Site No. 1 Cultivated. June 30, 1955.

Location: Alachua Co., Fla. High Springs.

Vegetation: Garden plot, fallow.

Texture: fine sand

Nematodes Found:

Criconemoides sp.

Helicotylenchus sp.

Meloidogyne sp.

H-2. Lakeland Series. Site No. 2 April 12, 1957.

Location: Alachua Co., Fla. NE 1/4 of NW 1/4, Sect. 1, R20E, T10S.

Vegetation: Cultivated - tomatoes, St. Augustine grass.
Uncultivated - turkey oak, wiregrass.

Depth of Sample: 0 - 8 in.

Texture: fine sand

Nematodes Found:	Cultivated	Uncultivated
Longidorus elongatus	-	+
Trichodorus christiei	+	-
Xiphinema americanum	+	+

TABLE D (Continued)

H-3. Lakeland Series. Site No. 3 Uncultivated. March 20, 1956.

Location: Alachua Co., Fla. near Fairbanks.

Vegetation: Slash pine, wiregrass.

Depth of Sample:	0 - 6 in.	6 - 12 in.	12 - 18 in.
Texture:	fine sand	--	--
Nematodes Found:			
Belonolaimus sp.	+	+	+
Hoplolaimus coronatus	+	+	+
Meloidodera floridensis	+	+	-
Trichodorus christiei	+	-	+
Xiphinema americanum	-	+	+

H-4. Lakeland Series. Site No. 4 Cultivated. February 17, 1956.

Location: Levy Co., Fla. near Bronson.

Vegetation: Tobacco, preceded by corn.

Texture: fine sand

Nematodes Found:

Belonolaimus sp.
Criconemoides sp.
Trichodorus sp.
Xiphinema sp.

I-1. Orlando Series. Site No. 1 Cultivated. August 7, 1955.

Location: Orange Co., Fla.

Vegetation: Centipede grass.

Texture: fine sand

Nematodes Found:

Belonolaimus sp.
Longidorus sp.
Meloidogyne sp.
Pratylenchus sp.
Xiphinema sp.

TABLE E

NEMATODES FOUND IN WELL-DRAINED LIMESTONE
AND POORLY DRAINED MARLS

A-1. Perrine Series. Various Sites. Cultivated.

Location: Dade Co., Fla.

Vegetation: Beans, turnips. Number of Samples: 6

Nematodes Found:	Number Samples Found In:
Helicotylenchus (H. nannus)	6
Hoplolaimus coronatus	1
Tylenchorhynchus sp.	1

TABLE F

NEMATODES FOUND IN OTHER SOILS[a]

A-1. Alachua Series. Site No. 1 Cultivated. September 16, 1957.

Location: Alachua Co., Fla. 0.4 mi. North Seaboard Railway on Sect. 20-21 boundary, R18E, T8S.

Vegetation: Bahia pasture, Cassia tora.

Depth of Sample: 0 - 8 in.

Texture: loamy fine sand

Nematodes Found:

Criconemoides rusticum
Meloidogyne sp.
Tylenchus costatus
Xiphinema sp.

A-2. Alachua Series. Site No. 2 Cultivated. September 17, 1958.

Location: Alachua Co., Fla. NW 1/4 of NE 1/4, Sect. 14, R18E, T9S.

Vegetation: Bermudagrass pasture.

Depth of Sample: 0 - 6 in.

Texture: loamy fine sand

Nematodes Found:

Criconemoides rusticum
Helicotylenchus nannus
Hoplolaimus coronatus
Meloidogyne sp.
Pratylenchus brachyurus
Trichodorus christiei
Tylenchorhynchus sp.
Xiphinema longicaudatus

[a]One sample per site or depth unless otherwise indicated.

TABLE F (Continued)

B-1. Archer Series. Site No. 1 Uncultivated. July 28, 1958.

Location: Suwannee Co., Fla. NW 1/4 of NE 1/4, Sect. 35, R13E, T3S.

Vegetation: Longleaf pine, turkey oak, wiregrass.

Depth of Samples:	0-4 in.	4-8 in.	8-18 in.	24-32 in.	32-37 in.
Texture:	sand	sand	loamy sand	sandy clay loam	sandy clay loam
Percent sand:	91.0	92.5	82.6	76.4	76.0
silt:	6.8	4.7	9.0	3.4	2.4
clay:	2.2	2.8	8.4	20.2	21.6
pH.	5.3	5.6	5.5	5.0	5.0
Nematodes Found:					
Helicotylenchus sp.	+	-	-	-	-
Helicotylenchus nannus	-	+	-	-	-
Hemicycliophora typica	-	+	-	+	-
Hemicriconemoides wessoni	-	+	+	+	-
Longidorus sp.	-	+	+	+	-
Scutellonema sp.	-	-	-	+	-
Scutellonema christiei	+	+	+	-	-
Trichodorus sp.	+	-	-	-	-
Trichodorus christiei	-	+	-	-	-
Xiphinema sp.	+	-	+	-	+
Xiphinema americanum	-	+	-	+	-

TABLE F (Continued)

B-2. Archer Series. Site No. 2 Cultivated. July 28, 1958.

Location: Suwannee Co., Fla. Across graded road just opposite site of B-1.

Vegetation: Corn, tobacco.

Depth of Sample: 0 - 8 in.

Texture: loamy fine sand Number of Samples: 4

Nematodes Found:	Number Samples Found In:
Helicotylenchus (H. nannus)	2
Hoplolaimus coronatus	1
Longidorus sp.	2
Meloidogyne (M. incognita incognita)	1
Pratylenchus (P. brachyurus, zeae)	3
Scutellonema sp.	2
Tylenchorhynchus sp.	1
Xiphinema sp.	1

TABLE F (Continued)

B-3. Archer Series. Site No. 3 Uncultivated. July 28, 1958.

Location: Suwannee Co., Fla. NE 1/4 of SW 1/4, Sect. 21, R13E, T2S.

Vegetation: Pine, partridge pea, sedges.

Depth of Samples:	0-8 in.	8-18 in.	18-22 in.	+ 22 in.
Texture:	fine sand	fine sand	sandy clay loam	clay
Per sand:	91.1	93.0	64.8	43.0
silt:	6.7	4.9	6.4	10.4
clay:	2.2	2.3	28.8	46.6
pH.	5.5	5.6	4.7	4.7
Nematodes Found:				
Criconemoides rusticum	-	+	+	+
Dolichodorus heterocephalus	-	+	-	-
Helicotylenchus erythrinae	+	-	-	-
Hemicycliophora sp.	-	+	-	-
Hoplolaimus coronatus	+	-	-	-
Longidorus elongatus	-	+	+	+
Meloidogyne sp.	+	+	-	-
Pratylenchus brachyurus	+	-	-	-
Pratylenchus zeae	+	-	-	-
Scutellonema christiei	+	+	+	-
Trichodorus proximus	+	-	+	-

TABLE F (Continued)

B-4. Archer Series. Site No. 4 Cultivated. July 28, 1958.

Location: Suwannee Co., Fla. In tobacco field 250 ft. west of B-3.

Vegetation: Tobacco.

Texture: fine sand

Nematodes Found:

Ditylenchus sp.

Helicotylenchus erithrinae

Meloidogyne incognita acrita

Pratylenchus brachyurus

Pratylenchus zeae

Trichodorus proximus

Tylenchus sp.

C-1. Alluvial fine sand. Site No. 1 Uncultivated. March 22, 1956.

Location: Alachua Co., Fla. NW 1/4 of NW 1/4, Sect. 27, R21E, T9S.

Vegetation: Sweet gum, maple, pine.

Nematodes Found:

Belonolaimus sp.

Hoplolaimus coronatus

Meloidodera floridensis

Sphaeronema sp.

TABLE F (Continued)

C-2. Alluvial. Site No. 2 Uncultivated. May 11, 1958.

Location: Jefferson Co., Fla. NW 1/4 of NE 1/4, Sect. 36, R4E, T3N.

Vegetation: Blackberry, elder, maple.

Depth of Sample: 0 - 12 in.

Texture: sandy clay loam

Percent sand:	63.8
silt:	9.0
clay:	27.2

Nematodes Found:

Pratylenchus zeae
Trichodorus christiei

D-1. Klej Series. Site No. 1 Cultivated. July 28, 1958.

Location: Suwannee Co., Fla. Suwannee Valley Experiment Station.

Vegetation: Bermudagrass.

Depth of Sample: 0 - 8 in.

Texture: fine sand

Percent sand:	93.0
silt:	5.5
clay:	1.5
pH.	4.4

Nematodes Found:

Criconemoides rusticum
Hoplolaimus coronatus
Pratylenchus zeae
Trichodorus christiei

TABLE F (Continued)

E-1. St. Johns Series. Site No. 1 Cultivated. January 23, 1956.

Location: St. Lucie Co., Fla.

Vegetation: Bermudagrass.

Texture: fine sand Number of Samples: 5

Nematodes Found:	Number Samples Found In:
Belonolaimus sp.	1
Dolichodorus heterocephalus	1
Helicotylenchus sp.	2
Hemicycliophora sp.	2
Trichodorus (T. christiei)	3

TABLE G

OCCURRENCE OF PLANT PARASITIC NEMATODE GENERA
IN SOIL SAMPLES FROM 39 FLORIDA COUNTIES

County - Alachua	Total Samples - 19
Nematodes Found	No. Samples Found In
Belonolaimus	13
Criconemoides	5
Helicotylenchus	9
Hemicriconemoides	1
Hoplolaimus	7
Pratylenchus	6
Trichodorus	8
Xiphinema	1
County - Baker	**Total Samples - 9**
Nematodes Found	No. Samples Found In
Hemicycliophora	1
Paurodontus	8
Scutellonema christiei	1
Trichodorus christiei	3
County - Bay	**Total Samples - 4**
Nematodes Found	No. Samples Found In
Belonolaimus	1
Hemicycliophora	1
Hoplolaimus	2
Pratylenchus	1
Trichodorus	1
Xiphinema	1

TABLE G (Continued)

County - Bradford	Total Samples - 1
Nematodes Found	No. Samples Found In
Aphlenchoides besseyi	1
Belonolaimus spp.	1

County - Brevard	Total Samples - 1
Nematodes Found	No. Samples Found In
Belonolaimus spp.	1
Hoplolaimus sp.	1

County - Broward	Total Samples - 3
Nematodes Found	No. Samples Found In
Belonolaimus spp.	1
Helicotylenchus spp.	1
Hoplolaimus sp.	2
Xiphinema spp.	2

County - Clay	Total Samples - 2
Nematodes Found	No. Samples Found In
Belonolaimus spp.	1
Criconemoides sp.	1
Helicotylenchus spp.	1
Hemicycliophora sp.	1
Hoplolaimus sp.	1
Xiphinema sp.	1

TABLE G (Continued)

County - Collier	Total Samples - 1
Nematodes Found	No. Samples Found In
Hoplolaimus sp.	1

County - Dade	Total Samples - 29
Nematodes Found	No. Samples Found In
Belonolaimus sp.	6
Criconemoides sp.	12
Helicotylenchus sp.	13
Hemicriconemoides sp.	2
Hoplolaimus sp.	9
Meloidogyne incognita acrita	1
Rotylenchulus reniformis	5
Trichodorus sp.	1
Xiphinema sp.	6

County - DeSoto	Total Samples - 3
Nematodes Found	No. Samples Found In
Criconemoides sp.	1
Hoplolaimus sp.	3
Trichodorus sp.	1
Xiphinema sp.	1

County - Dixie	Total Samples - 3
Nematodes Found	No. Samples Found In
Belonolaimus sp.	2
Criconemoides sp.	2
Trichodorus sp.	1
Xiphinema sp.	1

TABLE G (Continued)

County - Duval	Total Samples - 26
Nematodes Found	No. Samples Found In
Belonolaimus spp.	21
Criconemoides spp.	19
Dolichodorus heterocephalus	1
Helicotylenchus spp.	6
Hemicriconemoides wessoni	2
Hemicycliophora spp.	2
Hoplolaimus coronatus	37
Longidorus sp.	1
Meloidogyne spp.	5
Pratylenchus spp.	1
Trichodorus spp.	10
Tylenchorhynchus claytoni	1
Xiphinema spp.	1

County - Escambia	Total Samples - 1
Nematodes Found	No. Samples Found In
Heterodera sp.	1
Hoplolaimus sp.	1

County - Gilchrist	Total Samples - 1
Nematodes Found	No. Samples Found In
Xiphinema americanum	1

County - Highlands	Total Samples - 2
Nematodes Found	No. Samples Found In
Belonolaimus spp.	1
Hoplolaimus sp.	2

TABLE G (Continued)

County - Hillsborough	Total Samples - 12
Nematodes Found	No. Samples Found In
Belonolaimus spp.	8
Criconemoides spp.	7
Helicotylenchus spp.	1
Hemicycliophora spp.	1
Hoplolaimus sp.	11
Meloidogyne sp.	1
Trichodorus sp.	2
Tylenchorhynchus sp.	1
Xiphinema spp.	1

County - Indian River	Total Samples - 2
Nematodes Found	No. Samples Found In
Belonolaimus spp.	2
Criconemoides spp.	1
Helicotylenchus spp.	2
Hoplolaimus sp.	2
Trichodorus spp.	1

County - Lafayette	Total Samples - 1
Nematodes Found	No. Samples Found In
Xiphinema sp.	1

TABLE G (Continued)

County - Lake	Total Samples - 23
Nematodes Found	No. Samples Found In
Belonolaimus spp.	17
Criconemoides spp.	8
Helicotylenchus spp.	7
Hoplolaimus sp.	6
Longidorus sp.	1
Meloidogyne sp.	1
Pratylenchus spp.	1
Trichodorus spp.	9
Xiphinema spp.	2
County - Lee	**Total Samples - 6**
Nematodes Found	No. Samples Found In
Belonolaimus spp.	5
Criconemoides spp.	2
Hemicycliophora sp.	2
Hoplolaimus sp.	4
County - Leon	**Total Samples - 3**
Nematodes Found	No. Samples Found In
Criconemoides spp.	1
Helicotylenchus spp.	1
Pratylenchus spp.	1
Xiphinema sp.	2
County - Levy	**Total Samples - 2**
Nematodes Found	No. Samples Found In
Helicotylenchus spp.	1
Meloidogyne sp.	1
Trichodorus spp.	2
Xiphinema spp.	1

TABLE G (Continued)

County - Manatee	Total Samples - 4
Nematodes Found	No. Samples Found In
Belonolaimus spp.	2
Criconemoides spp.	2
Helicotylenchus spp.	2
Hemicycliophora spp.	2
Hoplolaimus sp.	2
Trichodorus sp.	2
County - Marion	**Total Samples - 8**
Nematodes Found	No. Samples Found In
Belonolaimus spp.	2
Criconemoides spp.	1
Ditylenchus sp.	2
Helicotylenchus spp.	3
Hoplolaimus sp.	3
Pratylenchus spp.	2
Trichodorus spp.	1
County - Martin	**Total Samples - 2**
Nematodes Found	No. Samples Found In
Criconemoides spp.	1
Pratylenchus spp.	1
Tylenchorhynchus sp.	1
County - Monroe	**Total Samples - 2**
Nematodes Found	No. Samples Found In
Criconemoides sp.	2
Hoplolaimus sp.	1

TABLE G (Continued)

County - Nassau	Total Samples - 1
Nematodes Found	No. Samples Found In
Criconemoides spp.	1

County - Orange	Total Samples - 66
Nematodes Found	No. Samples Found In
Belonolaimus spp.	34
Criconemoides spp.	32
Helicotylenchus spp.	9
Hemicriconemoides spp.	10
Hemicycliophora spp.	1
Hoplolaimus sp.	36
Longidorus sp.	5
Meloidogyne spp.	2
Pratylenchus spp.	19
Trichodorus spp.	16
Tylenchorhynchus spp.	4
Xiphinema spp.	6

County - Palm Beach	Total Samples - 5
Nematodes Found	No. Samples Found In
Belonolaimus spp.	4
Criconemoides spp.	3
Helicotylenchus spp.	2
Heterodera sp.	1
Hoplolaimus sp.	2
Meloidogyne sp.	1
Pratylenchus spp.	1
Trichodorus spp.	3
Xiphinema spp.	2

TABLE G (Continued)

County - Pinellas	Total Samples - 41
Nematodes Found	No. Samples Found In
Belonolaimus spp.	14
Criconemoides spp.	21
Helicotylenchus spp.	3
Hemicriconemoides spp.	2
Hemicycliophora sp.	4
Hoplolaimus sp.	28
Meloidogyne sp.	5
Scutellonema sp.	1
Trichodorus spp.	18
Tylenchorhynchus spp.	2
Xiphinema spp.	5

County - Polk	Total Samples - 14
Nematodes Found	No. Samples Found In
Belonolaimus spp.	8
Criconemoides spp.	11
Hemicycliophora spp.	4
Hoplolaimus sp.	11
Pratylenchus spp.	1
Trichodorus spp.	8

County - Putnam	Total Samples - 7
Nematodes Found	No. Samples Found In
Belonolaimus spp.	4
Criconemoides spp.	2
Helicotylenchus spp.	2
Hoplolaimus sp.	3
Meloidogyne spp.	1
Trichodorus spp.	2
Xiphinema spp.	1

TABLE G (Continued)

County - St. Johns	Total Samples - 1
Nematodes Found	No. Samples Found In
Criconemoides spp.	1
Hoplolaimus sp.	1
Trichodorus spp.	1
County - St. Lucie	**Total Samples - 20**
Nematodes Found	No. Samples Found In
Belonolaimus spp.	1
Criconemoides spp.	1
Helicotylenchus spp.	2
Hemicycliophora spp.	8
Pratylenchus spp.	4
Trichodorus spp.	12
County - Sarasota	**Total Samples - 15**
Nematodes Found	No. Samples Found In
Belonolaimus spp.	4
Criconemoides spp.	4
Dolichodorus sp.	1
Helicotylenchus spp.	3
Hoplolaimus sp.	10
Pratylenchus spp.	2
Scutellonema sp.	1
Trichodorus spp.	7
Tylenchulus sp.	1
Xiphinema spp.	4
County - Seminole	**Total Samples - 3**
Nematodes Found	No. Samples Found In
Belonolaimus spp.	2
Criconemoides spp.	1
Dolichodorus sp.	1
Hoplolaimus sp.	1
Tylenchorhynchus spp.	1

TABLE G (Continued)

County - Sumpter	Total Samples - 10
Nematodes Found	**No. Samples Found In**
Belonolaimus sp.	1
Helicotylenchus sp.	6
Hoplolaimus coronatus	6
Meloidogyne sp.	2
Pratylenchus sp.	1
Trichodorus sp.	8

County - Taylor	Total Samples - 3
Nematodes Found	**No. Samples Found In**
Belonolaimus spp.	2
Criconemoides spp.	2
Trichodorus spp.	2
Xiphinema spp.	1

County - Volusia	Total Samples - 19
Nematodes Found	**No. Samples Found In**
Belonolaimus spp.	5
Criconemoides spp.	2
Helicotylenchus spp.	1
Hemicyclophora	2
Hoplolaimus sp.	13
Pratylenchus spp.	2
Trichodorus spp.	3

TABLE H

NUMBER OF BELONOLAIMUS LONGICAUDATUS RECOVERED FROM SURVIVAL EXPERIMENT

Treatment	Nematodes Recovered Per Replicate				Total	Average
	A	B	C	D		
1. Arredondo subsoil	564	170	295	260	1289	322.2
2. Mixed soil, 15 % clay	26	60	50	74	210	52.5
3. Mixed soil, 30 % clay	1	5	11	43	60	15.0
4. Greenville subsoil	3	15	12	12	42	9.1
5. Everglades peaty muck	23	24	13	7	67	16.7
6. Flamingo silty clay	1	0	0	1	2	0.5
	Significant Difference (Tukey's D)				19:1	50.3

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(Abbreviations conform to the World List of Scientific Periodicals, Third Edition. Academic Press, New York. 1952.)

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BIOGRAPHICAL NOTE

Walter Hendrix Thames, Jr., the son of Walter Hendrix and Claude Dunn Thames, was born July 29, 1918, in Richmond, Virginia.

He attended grammar school in Thomasville, Georgia, and graduated from Thomasville High School in 1935. He commenced his college education at Emory at Oxford in September, 1935, and attended South Georgia College and Georgia School of Technology before his education was interrupted by World War II. He served in the United States Navy from December, 1940, to January, 1946, and was released to inactive duty with the rank of Lieutenant Commander.

In February, 1946, his college work was continued at the University of Florida where he earned the degree Bachelor of Science in Agriculture with High Honors in 1947 and the degree Master of Science with a major in Entomology and minor in Botany and Zoology in 1948.

In June, 1948, he was appointed Assistant Entomologist at the Everglades Experiment Station where he conducted research on soil borne insects and on nematodes. In February, 1955, he resigned to accept the Nematology Research Fellowship at the University of Florida.

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Mr. Thames is a member of the following professional and honorary societies: Helminthological Society of Washington, Society

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He married the former Joanna Marie Collins of Quincy, Massachusetts on May 2, 1943. They are the parents of two daughters: Margaret Dunn, born April 14, 1945, and Joanna Collins, born July 6, 1950.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Agriculture and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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